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SEA LILIES.

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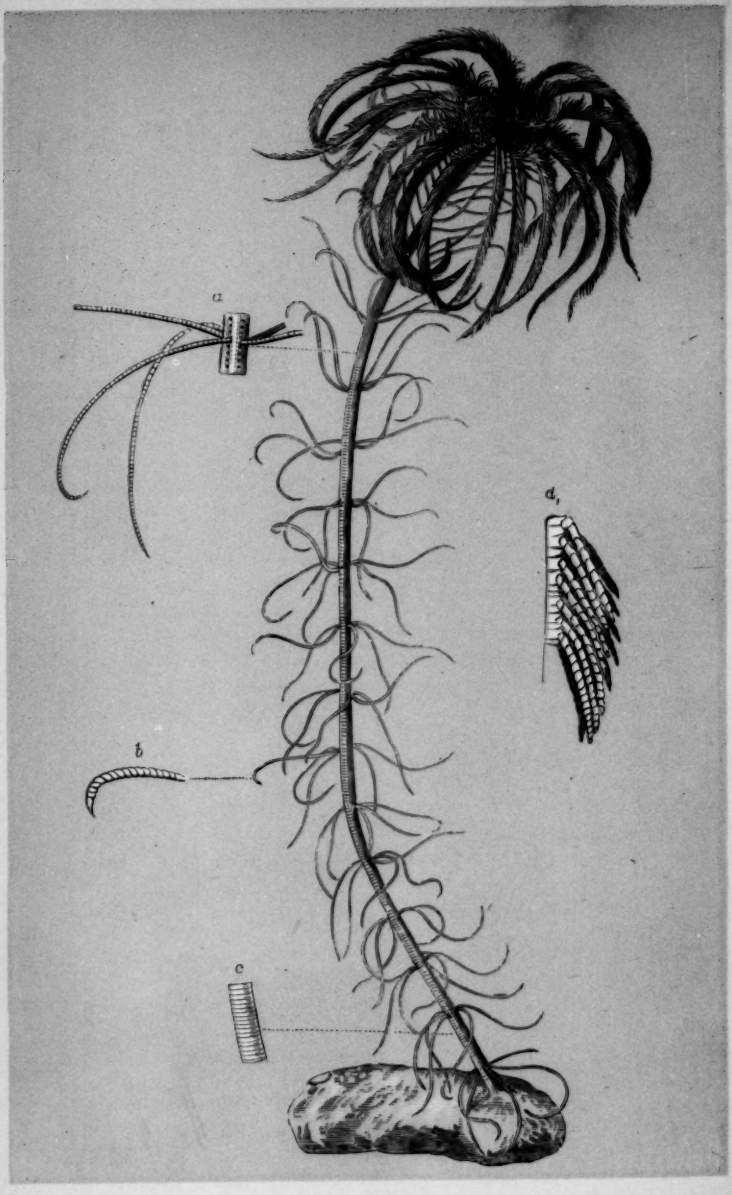
(*With a Tinted Plate.*)

UNDER a tall glass shade on the top of one of the Echinoderm cases in Room II. of the northern Zoological gallery in the British Museum, there is a beautiful plant-like organism, which, from its prominence and style of mounting, seems to be held of great account even in that room, into which all the sea holds rare or beautiful among its urchins and sea-stars are congregated.

At a first glance one might imagine that some cunning worker in mosaic had modelled a strange exotic lily, piecing it together of thousands of minute symmetrical blocks of pale yellowish terra-cotta. A tall stem, formed of a multitude of rounded or slightly pentagonal joints, supports a shallow plated cup, from whose rim there arises a crown of gracefully curving arms. These arms divide and re-divide, and each division is closely fringed on either side with smaller branchlets, spreading from the arm like the barbs from the quill of a feather. On the left-hand side of the door of the same room there is a tall glass jar containing a specimen of the same species in spirits, and on the right-hand side there is a glazed case with two dried specimens hanging in it, resembling the other two in general appearance, but so different from them in many respects as to require to be placed in a separate sub-generic group.

These four specimens are of surpassing interest both to the zoologist and to the palæontologist. They represent the only two known living species of a group of the Echinoderms, the STALKED CRINOIDS, which lived in myriads, and passed through a marvellous series of modifications in form, during



Pentacrinus Caput-Medusæ. Mill. One-third natural size.
St. Lucia. West Indies.

Drawn by Mr. J. Dinkel from a specimen in the British Museum.

some of the past periods of the earth's history. So abundant were they that deep beds of limestone were often formed by the gradual accumulation of little else than their skeletons, the stem-joints and cups cemented together by limy sediment.

During the lapse of ages the whole order seems to have been worsted in the "struggle for life." They become scarce in the newer Mezozoic beds, still scarcer in the Tertiaries, and in the seas of the present period the two living stalked Crinoids appear to be confined to the deep water off the outer Antilles, whence the fishermen from time to time recover mutilated specimens entangled on their lines. They seem, however, to be rare. Their occurrence has been known for more than a century, and although many eyes have been watching for them, only about twenty specimens in all have reached Europe. Only two of these show all the joints and plates of the skeleton, and the soft parts are lost in all.

An aberrant group of the Crinoids, the Comatulidæ, attached by stems only in their early youth, and afterwards becoming free and swimming about, seem to have started up about the middle of the Mezozoic period, and to have gathered strength with the decadence of their fixed predecessors. This group is generally though meagrely distributed in modern seas. Its head-quarters seem to be near the verge of the Arctic Circle, but every here and there in sheltered bays along the coasts of Britain, the dredger falls in with colonies of two pretty little representatives, "Miller's" and the "rosy" feather-stars.

I will describe in the present communication the general structure of the West Indian stalked Crinoids, and sketch the singular relation which they bear to the feather-stars of our Northern seas.

Our Plate represents the specimen under the glass shade in the northern Zoological gallery. This species has been known in Europe since the year 1755, when a specimen was brought to Paris from the island of Martinique, and was described by Guettard in the *Memoirs of the Royal Academy of Sciences*. For the next hundred years an example turned up now and then from the Antilles. Ellis described one, now in the Hunterian Museum of Glasgow, in the *Philosophical Transactions* for 1761. One or two found their way into the museums of London, Copenhagen, Bristol, and Paris, two into the British Museum, and one fortunately fell into the hands of the late Professor Johannes Müller, of Berlin, who published an elaborate account of it in the *Berlin Academy Transactions* in 1843. Within the last two or three years Mr. Damon, of Weymouth, a well-known and excellent collector and distributor of objects of natural history, has procured three very good specimens. One of these is now in the Imperial Museum of Moscow, another

is in the Liverpool Museum, and the third in the museum of Queen's College, Belfast.

This form has usually been described under the name of PENTACRINUS *Caput-Medusæ*. Another and a widely different species, PENTACRINUS *Briareus*, from the Lias of the south of England, seems, however, to have a just claim to be recognized as the type of the genus Pentacrinus. I think there is great advantage in retaining old and well-known generic terms to indicate marked groups of allied forms; I shall, therefore, merely propose for this species, and one or two fossils which closely resemble it, the rank of a sub-genus, CENOCRINUS.*

CENOCRINUS *Caput-Medusæ* (Mill.) consists of two well-marked divisions, a stem and a head. In the specimen figured the stem seems to rise from a crevice in a stone. There is no doubt that the animal when living is attached to some solid body, but there are good reasons for suspecting that in the present case the attachment is artificial. The stem of this specimen was probably originally much longer; and, from the analogy of fossil species, it was most likely attached by a wide base. The stem consists of a series of flattened joints; it may be snapped over at the point of junction between any two of these joints, and by slipping the point of a penknife into the next suture, a single joint may be removed entire. The joint has a hole, through which one might pass a fine needle in the centre. This hole forms part of a canal, filled during life with gelatinous nutrient matter, which runs through the whole length of the stem, branches in a remarkable way through the plates of the cup, and finally passes through the axis of each of the joints of the arms, and of the ultimate pinnules which fringe them. On either surface of the stem-joint there is a very graceful and characteristic figure of five radiating, oval, leaf-like spaces. Each space is surrounded by a border of minute alternate ridges and grooves. The ridges of the upper surface of a joint fit into the grooves of the lower surface of the joint above it; so that though, from being made up of many joints, the stem admits of a certain amount of motion, that motion is very limited.

As the border of each star-like figure exactly fits the border of the star above and below, the five leaflets within the border are likewise placed directly one above the other. Within these spaces the limy matter which makes up the great bulk of the joints, is more loosely arranged than it is outside, and five oval bands of strong fibres pass right through the joints, from joint to joint, from one end of the stem to the other. These fibrous bands give the column its great strength; it is

* From two Greek words, καινος, recent, and κρινον, a lily.

by no means easily broken, even when dead and dry. They also by their elasticity admit a certain degree of passive motion. There are no muscles between the joints of the stem, so that the animal does not appear to be able to move its stalk at will. It is, probably, only gently waved by the tides and currents, and by the movement of its own arms. In the upper and newer part of the stem five series of strongly-marked pores pass inwards between the stem-joints at the bottom of the five longitudinal grooves. The function of these pores is unknown.

In *C. Caput-Medusæ* about every seventeenth joint of the lower, mature part of the stem is a little deeper, or thicker, than the rest, and bears a whorl of five long tendrils, or *cirrhi*. The stem is, even near the base, slightly pentagonal in section, and it becomes more markedly so towards the head. The cirrhi start from shallow grooves between the projecting angles of the pentagon, so that they are ranged in five straight rows up and down the stem. The cirrhi are made up of about thirty-six to thirty-seven short joints. They start straight out from the stem, rigid and stiff, but at the end usually curve downwards, and the last joint is sharp and claw-like. These tendrils have no true muscles; they have, however, some power of contracting round resisting objects which they touch, and there are often star-fishes and other sea monsters entangled in them. Near the head the cirrhi become shorter and smaller, and their whorls closer. The reason of this is that the stem grows immediately below the head, and the cirrhus-bearing joints only, are formed in this position, the intermediate joints being produced afterwards below each cirrhated joint, which they gradually separate from the one beneath it till their number of seventeen or eighteen is complete.

At the top of the stem five little calcareous lumps like buttons stand out from the projecting ridges, and upon these, and upon the upper plate of the stem, the cup which holds the true body of the animal is placed. These buttons are of but little moment in this form, but they represent parts which are often developed into large highly ornamented plates in the various tribes of its fossil ancestors. They are called the *basal* plates of the cup. Next, in an upper tier, we have a row of five oblong plates opposite the grooves of the stem, and all cemented together in a ring. These plates are separate when the animal is young. They are called the *first radial* plates. They are the first of long chains of joints which are continuous to the ends of the arms. Immediately above these plates and resting upon them there is a second row of plates nearly of the same size and shape, only they remain separate from one another, never coalescing into a ring. These are the *second*

radials, and immediately upon these rest a third series of five, very like the plates of the other two rows, only their upper surfaces rise into a cross ridge in the centre, and they have the two sides bevelled off like the eaves of a gable, to admit of two joints being seated upon each of them instead of one. This last series of plates are the *radial axillaries*, and above these we have the first bifurcation of the arms. These three rings of radial plates form the true cup. In the modern species they are very small, but in many fossils they acquire a large size, and enclose, frequently with the aid of various rows of intermediate or *interradial* plates, and of a row of basals, a large body-cavity. The two upper plates of each ray are separated from those of the ray next it, by a prolongation downwards of the plated skin which covers the upper surface or *disk* of the body, and which will be described forthwith.

Seated upon the bevelled sides of each radial axillary plate there is a series of five joints, the last of the five bevelled again, like the radial axillaries, for the insertion of two joints. These five joints are the *first brachials*, and from the base of this series the arm becomes free. The first of the brachial joints, that is to say, the joint immediately above the radial axillary, is, as it were, split in two by a peculiar kind of plate joint, called by Müller a syzigie. All the ordinary joints of the arms are provided with muscles, producing various motions, and binding the joints firmly together. The syzigies are not so provided, so that the arms are easily snapped across where these occur. This is a beautiful provision for the safety of an animal which has such a wide and complicated crown of appendages. If one of the arms get entangled, or fall into the mouth or claw of an enemy, by a jerk the star-fish can at once get rid of the embarrassed arm, and as all this group have a wonderful power of reproduction of lost parts, the arm is soon restored. When the animal is dying, it generally breaks off its arms at these syzigies, so that almost all the specimens which have been brought to Europe, have arrived with the arms separate from the body. About six arm-joints or so above the first, on either branch, there is a second *brachial axillary*, and a second bifurcation, and on the joint above it another syzigie, and seven or eight joints farther on, another, and so on, but more irregularly the farther from the centre, till each of the five primary rings has divided into from twenty to thirty ultimate branches, producing a rich crown of more than a hundred arms. Each division, counting from the radial axillary to the tip, is formed of upwards of a hundred joints. The upper surface of the arm-joint is deeply grooved, the lower arched, and from one side of each, alternately, on either side of the arm, there is jointed a series of from about fifteen in the middle of

the arm, to five or three near the end, flattened joints. These form the alternate branchlets or *pinnules*, tapering towards the tip, grooved along the inner side, the rows curving upwards on either side and tending to arch over the grooves of the arms. Each joint of the pinnules bears on its upper and outer angle a short projecting spine, so that the feather which the pinnules form by pluming the central rachis of the arm, has an extremely rich and pretty effect.

Most unluckily, all the specimens of *C. Caput-Medusæ* which have reached Europe have the soft parts destroyed, and the disk, or upper surface of the body, more or less injured. From the light which the structure of allied forms has thrown upon such fragments as have from time to time remained attached to the stronger parts of the skeleton, we are able, however, to restore the missing portions with tolerable certainty. The body is covered above by a membrane, uniformly tessellated with irregularly formed flat plates. This membrane, after covering the disk, dips into the spaces between the series of radial plates, and, with the plates of the cup, completes the body-cavity. The mouth is a rounded or pentagonal aperture of considerable size in the centre of the disk, and is surrounded by a ring of five triangular tooth-like plates, their angles meeting in the centre. Only one known specimen (in the collection of M. Michelin, in Paris) shows these *oral* plates, and that specimen is not in a satisfactory condition for examination. From the analogy of the young of some other forms, some such arrangement might almost have been anticipated in this species. The mouth opens into a stomach surrounded by a dark mass of liver, and a short curved intestine leads to an excretory tube upon the surface of the disk, near the mouth. From the mouth five, six, or seven deep grooves, bordered on either side by a row of small square plates, run out to the edges of the disk, and are continuous with the grooves on the upper surface of the arms. They divide at each bifurcation of the arms, and send branches along the grooves of all the arm pinnules. In these grooves lie the vessels of the water-vascular system, which is so characteristic of the Echinoderms. The radiating vessels arise from a central ring round the throat, and in their course they give off a most complicated and beautiful series of radial and brachial tentacles and respiratory leaves. In the star-fishes and sea-urchins, the class-mates of the Crinoids, the ovaries are placed within the body. In the Crinoids, or, at all events, in most of them, and certainly in all the modern forms, they are developed at certain seasons all over the arms, as separate little sacs, full of eggs, beneath the water-vessel on the inner surface of each of the pinnules. This "vegetative repetition," as it has been called, of one of the organs, seems to indicate a lower

type of organization for this group, and has, among other reasons, induced zoologists to place the order CRINOIDEA at the base of the Echinoderm series.

I must now ask my reader's attention to the two dried Encrinites in the glazed case at the right-hand side of the door. At first sight these look very much like the others, but they differ from them in so many remarkable particulars that I regard this species as the type of another sub-generic group, and shall describe it under the name of PENTACRINUS (NEOCRINUS*) *decorus*.

The general arrangement of the parts of the stem is the same in this species as in the last, but in the mature part of the stem the joints between the whorls of cirrhi are only twelve in number, and at each "node" two joints of the stem are modified to bear the cirrhi, the sutures between them partaking of the character of a syzigie, so that the animal seems to have the power of detaching itself at any of these points. The stem-cirrhi, from the nature of their attachment, do not project at right angles from the stem, but at once curve downwards. The cirrhi are much shorter and more flexible than in *P. Caput-Medusæ*. I have a beautifully perfect specimen of this species before me as I write, for which I am indebted to Mr. Damon, who procured it a few months ago from the seas of the outer Antilles. Mr. Damon at once recognized its distinctness from the more common form, and kindly forwarded it to me for examination. The lower portion of the stem (which is about two feet in length) is porcellanous, and covered with parasitic corallines, so that the active life of this part seems to have been over. The final joint (the upper joint of a nodal pair) is worn and rounded. Although it was, doubtless, attached in its early days, it appears to have finally parted from its attachment, and to have led a free life. The great flexibility and delicacy of the stem are suited to this change. The structure of the cup is nearly the same as in the former species, though the plates are different in form. The arms do not divide so frequently; there are only about thirty ultimate branches. Syzigies occur at irregular intervals of a few joints all along the arms, so that, while the arms of *C. Caput-Medusæ* generally arrive pretty entire, those of *N. decorus* tend to break into a multitude of fragments. The disc is fortunately perfect; instead of being closely paved, calcareous blocks like fragments of perforated bricks are scattered irregularly over a naked perisom. The mouth is entirely unarmed; the plates bordering the grooves are narrow and spine-like.

I have now described generally the structure of the two

* Νεον, recent, and κρινον, a lily.

stalked Crinoids which are met with living in the seas of the present period. So far as we yet know, these are the only remaining representations of the vast assemblage of widely-varying types which thronged the seas of past ages, with the exception, perhaps, of a species of Bourgueticrinus, a singular genus, whose remains are found abundantly in the white chalk, and of which a few joints are said to have been recovered from deep water in the West Indian seas. I shall conclude the present communication with a brief sketch of the curious zoological relations which these forms bear to the free Crinoids, the feather-stars. COMATULA *rosacea* is the most common British species. It is found abundantly in Lamlash Bay, in Arran, in Belfast and Strangford Loughs, in Dalkey Sound, in Kirkwall Bay, and generally distributed, though less abundant, in deep water all round the British and Irish coasts. In general structure it resembles very closely the head of NEOCRINUS *decorus*. The cup is formed nearly the same way, and of corresponding plates, only the basal plates do not show externally, and the first row of the radials are also concealed, so that the cup seems from the outside to consist of only one row of radial plates, succeeded immediately by the radial axillaries. At this point, as in NEOCRINUS, the arms bifurcate, but they divide no further, so that the arms are finally ten in number. The arm-joints are sharply wedge-shaped, and the pinnules are arranged as in the other species. As in NEOCRINUS, the arms are broken up by irregularly-placed syzigies. Comatula has no stem, but in the position of the stem, and forming the base of the cup, there is a hemispherical plate covered with rows of cirrhi, exactly like the stem-cirrhi in the stalked forms. This plate represents the stem, or rather the cirrhus-bearing joints of the stem condensed and fused together. The cirrhi are flexible, and evidently, to a certain extent, under the control of the animal.

The COMATULA, when at rest, holds on by them to a stone or weed, spreading out its beautiful, feathery, crimson arms, like the petals of a flower. When it chooses, however, it can let go its hold and swim rapidly through the water by graceful impulses of its arms. In spring, the hundreds of ovaries scattered over its pinnules are turgid with eggs, and if at this time it is captured and placed with some sea-weed in a tank, bunches of bright orange eggs are protruded from all the openings of the ovaries, where they hang in clusters, giving the delicately pinnatic arms the appearance of the fronds of some wonderfully graceful fern in rich fructification.

The phases passed through by the rising generation before they come to resemble their parent in form and mode of life, are of extraordinary beauty, and most instructive in determin-

ing the true zoological relation which the modern free Crinoids bear to their fixed ancestors. At first a minute, almost invisible, pale yellow germ escapes from the egg. This germ swims, or rather rolls about, in the water, and gradually becomes larger, till under the microscope, about the end of the first day after its birth, it has a very definite form, not the least like a star-fish—more like a little glass shoe, with a wider end, and a narrower end for the heel, and an oblong hole to put in the foot. This hole is the creature's mouth. Four bands of long vibratile cilia gird the body at different points, and by their motion, hour after hour, the little animal whirls about in the water, feeding, and leading a thoroughly active life. About the end of the second day two rows, of five each, of delicate calcareous trellised plates may be seen, making a kind of five-sided basket within the wider end of the shoe, and behind these a series of five or six open rings run back in a line to the heel, where they seem to abut against a larger plate. A dark mass now collects within the trellised basket, and the rings are united together by little bundles of limy rods, till they form what looks like a jointed pillar supporting the basket. All this time the little gelatinous being, within whose body these changes are taking place, swims about in the water and feeds, apparently utterly unconscious of the growth of a guest within, which is steadily compassing its destruction. Gradually, however, the plates within the wider end enlarge and distort the outer wall. The stem-like series of joints lengthen, stretching out the narrow end with it. The old mouth disappears, the gelatinous wall settles round the little living skeleton, a round sucker appears in the original position of the "heel," and the animal fixes itself upright to a sea-weed or to a stone at the bottom of the tank. Five leaf-like valves, each supported by one of the upper tier of plates, now open on the top of the wider extremity, and the little creature looks when these valves are open much like a microscopic wine-glass, and when they are closed, like a tulip bud.

A little stalked Encrinite has thus been mapped out and gradually developed within the gelatinous "pseud-embryo" produced from the egg of COMATULA. The five plates of the lower row are the basalia, these afterwards become hidden. The plates of the upper row correspond with the five triangular plates round the mouth of CENOCRINUS. These afterwards disappear. The upper joint of the jointed column, beneath which the stem is added to as it increases in length, by the development of new joints, passes into the centro-dorsal plate of COMATULA, and represents *all* the cirrhigerous stem-joints of the stalked Crinoids; and the rest of the stem-joints

represent the series of joints between any two nodes. A third row of small plates shortly appear between, and alternating with, the two first rows. These are the first radials, they are hidden by the centro-dorsal plate in the mature form. At the same time a mouth becomes evident in the centre of the upper row of plates, and a circlet of delicate flexible hollow tentacles, the first indication of the growing arms, fall curving over the edge of the cup. Two more radial joints are next formed; then the arms bifurcate; pinnules begin to appear, and at length we have a perfect miniature COMATULA, about half an inch across from tip to tip of the arms, fixed to a stone or weed by a jointed calcareous stem sometimes nearly an inch long. We have already seen how closely COMATULA resembles in structure the heads of the great stalked Crinoids; in its embryonic or larval condition, fixed by a stem to the ground, the resemblance is complete. The permanent ring at the top of the stem of the young COMATULA throws out cirrhi, and goes on growing into the centro-dorsal plate, and, finally, the connection between this plate and the next joint of the stem gives way, and the young COMATULA swims once more free.

I have now rapidly sketched the structure of the three typical representatives of the almost lost group of Crinoids which are now found living—CENOCRINUS, NEOCRINUS, and COMATULA. In the first type there can be little doubt, from the great strength and rigidity of the stem, and from the absence of all provision for its rupture, that the animal is stalked and attached for life. The arms are greatly multiplied, large and strong. No syzigies, save those at the base, which can be used on an emergency, tend to diminish their strength—an arrangement essential to the full supply of food in their fixed condition. The disk is uniformly defended and plated with calcareous pavement, and the mouth is armed with teeth for the destruction of any wanderer whose fate may lead him within the ruthless circuit of the net-like arms.

In NEOCRINUS there is an evident arrangement for the rupture of the stem in the syzigie between the upper nodal joint, to which the cirrhi are actually attached, and the lower joint, which is grooved to suit their curve in starting from the stem. This syzigie is between the nodal and the first internodal joint, and therefore exactly in the position in which the same provision for the severance of the stem occurs in the Cenocrinoid stage of COMATULA. We have evidence from the existence of this provision, and from observation, that at a certain period of its life NEOCRINUS becomes free. The number of arms in this second type is greatly less, and the arms are provided throughout with syzigies, an arrangement apparently suitable to its greater liability to trivial accidents in its free condition. The mouth is

unarmed, its liberty giving it a greater choice of food; and the disk is comparatively unprotected.

At first I had some doubt as to the propriety of making this species the type of a new sub-genus, and any one of the above characters would certainly not have afforded sufficient grounds; but all these characters taken together form a remarkably compact assemblage, which places NEOCRINUS in a directly intermediate position between CENOCRINUS and COMATULA. COMATULA becomes free, and gains its liberty by a rupture of the stem between the representative of a cirrhigerous joint and the upper joint of the only developed inter-node; it has few arms, provided with syzigies to the end; its disk is usually nearly naked; and its mouth is unarmed.

Here then we have apparently three marked types, the two last partaking in different degrees of the same form of deviation from the first, and from the general character of the main body of their order. In such a case one would certainly be strongly inclined to trace all the closely allied forms to a common ancestry, and to attribute each special deviation to the sum of an infinite series of minute variations. And yet the life history of the Crinoids does not seem as a whole to give unqualified support to the Darwinian theory. Certainly one of the strongest points in this hypothesis is the production of variation by "natural selection." From the beginning almost all the Crinoids have been permanently stalked, and entirely dependent for the fertilization of their eggs upon particles derived from any source, and scattered at random in the water of the sea. Under these circumstances the principle of natural selection cannot come into play, and we should anticipate that a group so circumstanced, would vary much more slowly and to a less marked degree than its locomotive cotemporaries. Now it so happens, that far from this being the case, the Crinoids during the lapse of geological time have run through a wild series of modifications, while the locomotive Echinoderms, from the lower Silurians upwards, do not differ very greatly, at all events in external form, from those of the present day.

PLATE (see frontispiece).—PENTACRINUS (CENOCRINUS) *Caput-Medusæ* (Mill.) *a*, portion of the upper part of the stem; *b*, the end of one of the stem-cirrhi; *c*, a portion of the stem near the base; *d*, a part of one of the arms, showing the arrangement of the pinnules.

MISSING CHAPTERS OF GEOLOGICAL HISTORY.

BY PROFESSOR D. T. ANSTED, F.R.S.

UNDER the title "Imperfection of the Geological Record" there is a striking and suggestive chapter in Darwin's *Origin of Species*, one result of which perhaps shows itself in the two anniversary addresses to the Geological Society, delivered by the President, Professor Ramsay, in the years 1863 and 1864. In these addresses the breaks in succession, or unconformities in the older and secondary strata, are considered with some care, the author connecting stratigraphical breaks with interruptions of the continuity of life and the converse.

In one sense it has always been admitted, by geologists and naturalists, that as the existence at a given time and in a given place of a certain group of animals or vegetables is, at the least, a proof of the general mutual fitness of the habits and structures of the organic to the conditions of inorganic existence, so any great change in the inorganic conditions must involve a corresponding change in the organic inhabitants. No doubt the interpretation of such a statement has been different by different writers, some assuming and endeavouring to prove that important change, either organic or inorganic, must be abrupt, cataclysmal, and manifest; while others believe that something inherent in the individual organism has during all time induced a modification of individuals and races as circumstances have rendered change desirable.

There was not wanting a certain amount of angry and alarmed declamation when it was first suggested that Nature, or rather the great Creator—the God of Nature—in the exercise of his Almighty Power in creation, may perhaps have instituted laws, the natural working out of which should result in a perpetual adaptation to incessant change. This view, simple enough, and certainly not tending to dishonour the Creator, but, on the contrary, imputing to Him the highest and greatest wisdom, cannot be regarded even now as generally admitted, but is gaining ground, and is perfectly consistent with, though by no means dependent on, a reception of the Darwinian doctrine of development by natural selection.

To discover the meaning and value of the breaks or interruptions that have taken place in the stratification even of a single group of deposits in any one country, it is beyond a doubt that the mind must be open to argument, and not hemmed in by preconceived notions. Geology, more than most of the natural history sciences, requires this condition of the intellect —this willingness to receive truth in whatever form it may

arrive; and in his addresses to the Geological Society on the subject of the breaks in succession of the British strata, Professor Ramsay was justified in supposing that his hearers would at once understand and be willing to admit whatever conclusions a fair consideration of the recorded facts on the subject might justify.

But in addition to the technical argument, presented in an abstract form by tabular documents, prepared for the occasion and since published, there is a more general, though not less important view that it is very desirable to set forth.

It will be evident that some definition of species, and of specified difference in reference to extinct species, must be adopted for the occasion of this discussion. Even if it be the case that species are derived one from another, there yet exists between any two recognized species a real difference and a marked departure from the normal and typical character. This we may regard as the practical equivalent to the essential and underivable difference assumed to exist by those who look on species as specially created and incapable of change. For the sake of convenience naturalists must continue to speak of species and regard them as distinct, even if the old notions be subverted and Darwinian views reign triumphant. On the other hand, if the reader be convinced that the derivation of species by natural means is not the habit of nature, he cannot deny, and will no doubt very readily admit, that there are many cases of strong analogy or resemblance between what he feels bound to regard as distinct species, and many others in which an affinity or relationship exists extremely puzzling and difficult to explain on any recognized anti-Darwinian theory. And this is so even where no specific identity of the ordinary kind seems possible.

If it be granted that certain points of difference in the structure and form of the skeleton or the shell of an animal, or of the corresponding parts in vegetable structures, really mark specific character or permanent varieties in all the principal divisions of the animal and vegetable kingdoms, we are justified in examining the fossils of the great series of stratified rocks with a view to comparison. If we find a group of remains (animal or vegetable) crowded in certain rocks, and absent from overlying or underlying rocks of similar mineral character, we may reasonably seek for an explanation of this in altered physical conditions. Either the depth of deposit has changed—what was once deep, being now shallow—or the converse; or a difference in the state of the water—salt water replaced by fresh, clear water by muddy, or the converse—has taken place.

If we find that in examining successive strata there are always differences in the groups of organic remains—that

groups are never actually repeated after an interval represented by rocks containing another group—that on the whole, as we recede from any geological horizon we depart more and more widely from the collection of organic forms that seem to characterize it, it becomes clear that breaks in the succession of strata are important and positive facts indicating lapses of time and well deserving careful study.

It is comparatively easy to trace such breaks in any one country after the first working out of the detailed geology of a country. It is, however, far more difficult to estimate their relative and positive value and construct a chronology from this sort of evidence. Nor is it easy to establish sound and useful comparisons between the succession and breaks in different countries which have been exposed to very different influences during the lapse of geological time. Any approach to so desirable a result is to be welcomed, and the elaborate tables recently published with respect to the Secondary rocks are of permanent value in this respect.

The old and familiar tripartite division of rocks into Palæozoic, Secondary or Mesozoic, and Tertiary or Cainozoic, is the best illustration of the more important and easily recognized of the breaks in succession. It was long a received doctrine that total and abrupt change in all forms of life marked the transition from any one to any other of these. More recently it has been admitted that there are a few species that pass from the older to the newer, but the number of such species is small in proportion. These great geological landmarks are still employed, and are as available now as they were when first proposed. The earliest interpretations of this method of grouping admitted and even assumed the change in species to be due to change of condition; but the change was regarded as essentially and of necessity cataclysmic, or belonging to some paroxysmal disturbance, destroying all that existed before and succeeded by a new creation.

Geologists have not altogether given up this view. Some of our French contemporaries have even within a few years insisted that every species in each formation was limited to one time and place, and the great maxim that "fossils are characteristic of formations" has thus been carried to an extreme. English geologists have been inclined to admit rather the probability of gradual change, and where there is marked difference in the kind of animal and vegetable life they believe that some intermediate bed has been deposited and removed, or that a long interval elapsed during which there were no deposits. It is these breaks that we have now to consider, so far as England is concerned.

For the most part marine deposits certainly represent con-

tinuous accumulation on a sea-bottom. That the depth, the nature of the material, the distance from the shore, the extent of life, development, and various other matters may have remained similar during similar accumulations, but was liable to change, and did constantly change, there can be no doubt. Such is the nature of all sea-bottoms now, and such must have been the case more or less through all time. Each principal formation thus represents thousands of sea-bottoms piled regularly one over another, slowly perhaps, and with occasional interruptions and slight changes of condition. During all this time other parts of the sea were receiving deposits. These no doubt were most like each other over a large area when the conditions were the same. The temperature of deep water is more uniform, the water is more still, the interruptions less considerable. Where then we find very wide areas and thick series of rocks very uniform in their nature and in the fossils contained, we may fairly assume the lapse of a long period, during which change was gradual.

On the other hand, where elevation or depression occurred, the conditions producing modifications of organic forms are present, and would be easily traceable. Where a great and important change occurred, such as the elevation of a continent with its mountain chain, we might well expect that the change should be total and extreme.

When now we pass in review the various deposits, bearing in mind these general conclusions, and assuming that the series is imperfect, but that whatever it indicated, whether directly or by inference, is not only truth but systematic truth, we shall see some light thrown on the great question of geological succession.

Commencing with the older or Palæozoic group of rocks, as developed in England, we find four recognized divisions in the established books on geology, known respectively as Silurian, Devonian, Carboniferous, and Permian. There are others recently introduced, but these we will speak of presently. Of these four it has generally been supposed that very few species are common to any two, and scarcely any to three. All forms of Silurian life are supposed to have vanished long before the end of the Carboniferous period, and breaks or strongly-marked interruptions, marking the lapse of long periods, are supposed to have occurred between the end of each one deposit and the beginning of the next. It is important that there should be a distinct notion as to the value of this idea. It lies at the base of many generalizations that require revision. It represents the belief of the paroxysmal school of geology, adopting and enforcing the idea that a special creation was required for each species of animal and vegetable, and that special groups of

species required to be introduced after certain important changes that resulted in the destruction of all living things. Without assuming that this view is incorrect, it is at least reasonable to inquire carefully what are the grounds of actual fact on which it depends.

The most ancient rocks hitherto determined within the range of the British Islands are certain deposits of gneiss in the north-west of Scotland. They are so completely metamorphosed, so far changed from their original condition of stratified fossiliferous deposits, that no fossils, no trace of organic contents, can at all be looked for in them. They repose, however, altogether unconformably, on other beds of gneiss, contorted and in the highest degree metamorphosed; and there can be no doubt that whatever the age of the overlying gneiss may be, that of the underlying rock is enormously greater. The older gneiss must have existed as gneiss, the strata must have been upheaved, denuded, depressed, and once more elevated; and they must have received the newer gneiss as a submarine mud before any other of the British rocks were formed. The newer gneiss is represented in Canada by rocks that contain fossil corals; at least, this is the opinion of the able geologists who have examined the specimens. The hiatus, then, that is indicated by the want of conformability between these two ancient masses of gneiss may be regarded as the earliest of the proved physical breaks in succession, and carries us back to a period very long antecedent to the so-called Silurian rocks with which geologists generally are familiar.

On the gneiss of north-western Scotland lie strata now called Cambrian. Similar rocks occur in Wales; but their actual identity with those of Scotland is not proved. As described by Sir Roderick Murchison, there appears to be a considerable interval in Scotland, where the absence of the Lingula flags, and the non-discovery hitherto of any fossils, renders it doubtful how far the whole series is present.

It is in the Lingula flags of Wales that we first come to deposits in any important sense fossiliferous. Here there are six genera and twenty species of Trilobites—remarkable and easily recognized animals, confined to Palæozoic rocks, but ranging through them, although becoming less important in the more modern deposits. After the Lingula flags, the immediately overlying deposits are strata long ago named by Professor Sedgwick the Tremadoc slates. In Wales these are covered by the Llandeilo and Bala Rocks, forming the Caradoc series. There are in the Tremadoc slate no less than eleven genera of Trilobites, seven of them distinct from those found in the underlying bed. All the species are different. A number of *Pteropoda* are also found in the upper, but none in the lower

series; and thus, though the number and variety of the fossils, both in the Lingula flags and Tremadoc slates, is but small, there is a nearly complete break both in genera and species, and this accompanied by unconformability in the deposits.

Between the Tremadoc slate and the Caradoc beds there is even a more marked difference. That the former is a very fragmentary, and probably a local deposit, is probable. But the great change in the organic contents is certainly a remarkable phenomenon, whether it results from an interruption of deposit or a denudation. In any case, both slates and flags are poor in fossils, except as regards Trilobites, which probably mark moderate depth of water. The Lingula flags, however, attain a thickness of 6000 feet in Merionethshire, and the Tremadoc beds are not unimportant. Both mark the lapse of considerable time, and the interval between the two must have been correspondingly great.

The lower Caradoc beds rest, apparently with conformity, on the upper Tremadoc slates. They afford not only many more species (the total number is thought to exceed 500), but much more variety; and though the Trilobites vary, the species generally are the same throughout. There is, however, another decided interruption where the Pentamerus beds of Llandovery (for the most part sands) overlie the Caradoc beds. With little evidence of want of conformability we find great change in the species. Thus, out of seventy known species, less than a fourth part (sixteen species) pass upwards from the Caradoc. The evidences of an important physical break at this point are very decided.

The middle Silurian series, as the Pentamerus beds of Llandovery are sometimes called, consist of the lower and upper Llandovery strata. The latter are chiefly conglomerates. They are cut off, with some clearness of definition, both by fossils and by unconformability, from the Caradoc sandstone on the one hand and the Wenlock shale on the other. Great mechanical disturbances had affected the lower beds before the Llandovery beds succeeded them, showing a marked stratigraphical break, supporting the evidence derived from a comparison of the fossils.

The upper Silurian rocks form a series of some five or six thousand feet of strata, including all varieties of mineral character, and loaded with organisms. It may be that the lower Silurians were deposited chiefly during depression, and the middle beds during a period of oscillation of level. Professor Ramsay distinguishes six divisions of the whole Silurian series, each separated from the underlying series by breaks, and each break believed to represent a lost epoch, unrepresented in our area.

In passing from Silurian to Devonian, there has always been a difficulty among English geologists; for we have the Old Red Sandstone in one part of the country, composed of sandstones and conglomerates, and, in another part, the Devonian shales. These great differences of mineral composition would of themselves ensure a marked change of organisms, and it is also probable that the typical Old Red of Herefordshire, the Old Red Sandstones of Scotland, and the beds believed to be contemporaneous in Devonshire, may belong to various parts of one great period. On the whole, it would seem probable that, during this long period of time, the sea-bottom in this part of the world was undergoing depression; but that this was accompanied by occasional elevation there can be little doubt, and thus considerable gaps occur, though they do not amount to physical breaks.

Besides the evidence of a break between upper Silurian and lower Devonian in England, we have in the south-west of Ireland, at the base of the Old Red Sandstone of that country, from 7000 to 10,000 feet of red beds, conformable to and overlying Ludlow, or upper Silurian rocks, and above half the thickness of other deposits, altogether unconformable, and passing up into the Carboniferous limestone. There is no representation of the deposits of the intermediate period in Ireland; although so great was the interval, that neither in fossils, nor in any physical relation, is there any connection between them. The Caithness flags in Scotland afford evidences of considerable breaks of stratification; but it is chiefly in the Pentland hills that the proof is to be found. There would seem, on the whole, no doubt that in all parts of the country where Devonian rocks or Old Red Sandstone occur, there are two well marked breaks at least between the commencement and close of the Devonian period.

Of the large number of species of upper Silurian fossils now known (amounting to several hundred), less than ten have been found in the lower Devonian, or immediately overlying rocks. That this almost total difference corresponds to a lapse of time during which the species gradually assumed new forms adapted to altered conditions, is the view of those geologists who endeavour to avoid the assumption of violent cataclysmic action; and this view is not rendered less probable by the mechanical and chemical changes that took place in the rocks between the completion of the one and the commencement of the other.

The Devonian rocks of England are not, on the whole, rich in fossils. The lower division (including the beds sometimes regarded as middle) yield 170 species, referred to sixty-one genera. Of these, twenty-three pass into the upper beds. These

yield in all sixty-five species, belonging to thirty-one genera; and of them about one-fifth (fourteen in all) pass upwards into the Carboniferous strata. Of the whole 215 Devonian species only eleven are common to Devonian and Carboniferous formations.

Within the great and important range of the Carboniferous rocks there are, on the other hand, hardly any breaks; all the important species ranging connectedly throughout, and there being very few extensive and decided indications of want of conformability in the stratification. Professor Ramsay doubtfully suggests one such break. There may be another; but it is, at any rate, clear that, on the whole, the deposit was continuous and the interruptions partial. The great coral reefs of the mountain limestone, the coarse sands and grit that succeeded, the alternating bands of clayey mud and vegetable matter of the coal measures—all these seem to point to a long period during which the sea-bottom, at first descending, was afterwards brought by degrees to the state of dry land undergoing great and important changes during the period.

Of more than a thousand species of Carboniferous forms of marine life, scarcely any pass into the Permian rocks; and of the few that do a large proportion are Brachiopoda. There can hardly be a doubt that a break of time is indicated, as well as a change in the state of the earth's surface. The few Permian plants are different from those of the coal measures; all the fish are distinct from those that abound in the mountain limestone; the whole deposit overlies and overlaps all the older rocks in turn; and everything helps to tell the same tale.

But almost immediately—for the Permian series is not very thickly developed in England, and, indeed, hardly deserves the name of series—we come to evidences of another great break, one of the two that divide principal groups of formations. Passing from Permian to the overlying and often conformable New Red Sandstone, we enter the Secondary period: a great mass of evidence proving that here again a very long break in time corresponded to the entire change induced in all forms of life. This evidence, however, is for the most part to be sought for out of England. Professor Ramsay has already, in former communications to the Geological Society, expressed an opinion that the dwarfed character, both of individuals and species, at this critical period of British geology, is the result of a period of cold admitting of the existence of glaciers in our latitude. There seems no new evidence in support of this view; but it is certain that all the conditions of existence had greatly altered from the time of the coal plants to that when the Labyrinthodon crawled over the sands near Liverpool, and the rock-salt of Cheshire was deposited.

That, on the whole, the fossils characteristic of the newer

Palæozoic rocks show an approximation to those of the Secondary period, is a fact to be understood only by tabulating and massing the various details, already very numerous, on which a general conclusion like this can be based. Thus, in comparing collections of fossils from the older divisions of the early period, as lower Silurian with Devonian, we find that genera are represented by very few species, and that there are many species in proportion to the number of specimens. In other words, there is a great variety of type-forms, but a poverty of actual representative forms. So again in the older rocks there is a preponderance of Brachiopodous over other mollusca; but in the Carboniferous groups the reverse is the case, especially with regard to species; though, if we estimate only the number of individual specimens in collections, the Brachiopoda are still preponderant. In the Permian rocks, few as the fossils are, they point to a continuance of the same change, and this in a marked manner. On the whole, we may say, that the proportion of species to a genus increases in all departments, not gradually and steadily, but suddenly, on entering the Carboniferous period, and again on entering the second stage of the great geological history. How far the nature of the sea-bottom, and the increasing deposits of calcareous matter in these parts of the world, may have affected the matter, it is not easy at present to say; but it hardly alters the conclusions we have arrived at.

There is no true stratigraphical passage in England from Permian to the New Red Sandstone formation, for, even when not unconformable, there is a distinct absence of some known member. The whole of the New Red Sandstone (the oldest Secondary formation) is also so exceedingly poor in fossils, in this country, that to form any idea of the deposits that represent the extraordinary break in the forms of life, it is necessary to borrow from Continental experience. There these beds are abundantly represented, and afford ample material for comparison. The St. Cassian beds, in the Italian Alps, sometimes considered to overlie the Muschelkalk, are the deposits that have chief relations with Palæozoic rocks. They have yielded a large number of species, of which the Brachiopoda are essentially of Palæozoic types. Of the other types of mollusca, many are common to the older and newer periods. The general result is, that one-third of the fossils are Palæozoic, and two-thirds Secondary, in general appearance. The Muschelkalk is far more essentially Secondary, and there has always been a doubt on the minds of geologists as to the exact position of the remarkable beds from these mountain districts.

It is only the upper bed of the Triassic period, known as the "bone bed," and long regarded as part of the Lias, that is rich in fossils in our country. It was not, indeed, till 1860

that the comparison of the molluscous remains from this part of the series was found so far to agree with previous determinations with regard to fish remains, as to demand its distinct classification with New Red Sandstone rocks. These beds are now recognized at the base of the Lias from Lyme Regis into the south of Leicestershire, and they may exist further towards Yorkshire, though hitherto they have not been described. They are very uniform in position, mineral character, and fossil contents, and have yielded upwards of sixty species. All these species differ from Muschelkalk species, but they are mostly of the same genera, and the aspect of the group is similar; while, on the other hand, without any lithological or stratigraphical break, there is only one species in common, between this bone bed and the lower Lias shales. There is, thus, a clear palæontological break between the bone bed and the lower Lias. The representative beds corresponding to this break are not yet discovered.

The Lias in England is a remarkably uniform deposit, consisting of muddy rocks converted into shales, and separated by bands more or less completely calcareous. The middle division, called the Marlstone, is the most like a limestone, and the uppermost part of the upper division is sandy.

Palæontologists have endeavoured to separate the Lias into a number of sub-divisions by the Ammonites, groups of species of these shells being characteristic of different zones. The evidence on this point rests on the assumption of specific differences being indicated by permanent modifications of the structure of the shell. But it is quite possible that these may mean nothing more than would be due to some change in the conditions of existence. Except between the Marlstone and the upper Lias there is really no palæontological break in the proper sense of the words. Alteration of form and size, consequent on the occurrence of circumstances more or less favourable, migration of species, and other well known causes, sufficiently account for many of those modifications of the form of the shell that have been taken as specific marks. This view is strengthened by the fact, that the other shells and other organisms generally show no proof of a break of any importance, except at the point already alluded to.

The Oolites overlie the Lias, but there is no clear and decided break between the upper Lias sands and the bottom beds of the inferior Oolite. This is well seen near Cheltenham, where passage beds occur. Bearing in mind that there is a considerable change of mineral character, the number of species (one-fifth of the whole) that pass from the upper Lias into the inferior Oolite is large, and the results of comparison of the other molluscous remains point to the same conclusion.

But the Oolites are wonderfully rich in fossils in England, and a careful tabulation of the species is more important in them, because the number known is, no doubt, a much larger proportion than usual of the whole.

Excluding plants, there are nearly 1500 Oolitic species, of which three-fourths lie in the lower Oolites, less than one-fourth in the middle, and only about one-fourteenth part in the upper beds.

Although a considerable percentage of the upper Lias species pass into the inferior Oolite, it must be understood that this is an exceedingly small proportion of the Oolitic species. In the older deposit (upper Lias) there are not more than about seventy species, and in the newer (inferior Oolite) there are almost five hundred. This much greater richness in species of the newer deposit would be even more remarkable if we counted individuals. In the upper Lias shales, fossils are comparatively rare, while the limestones of the inferior and great Oolites are made up almost exclusively of them.

Professor Ramsay gives a series of elaborate tables, prepared with the help of Mr. Etheridge, showing the distribution of species in the middle and newer part of the Secondary epoch. The results are in the highest degree interesting and valuable, and throw much light on the history of this remarkable period, certainly one of those best illustrated, by its deposits, of any that are known to geologists. For the purpose at present under consideration, the result of a careful study of these tables proves very clearly that no important palæontological break takes place from the Lias to the Portland rock, although during this time many species disappeared entirely, and many more had been introduced; some of these latter replacing others, which, however, so far as we can judge, must have existed under precisely analogous conditions. Each formation in succession, as we pass upwards, contains a number of species altogether new, mixed with a large number that have already existed in the earlier formation. Of the common species, some few pass through several formations; some disappear and re-appear, evidently owing to conditions temporarily unfavourable. In some cases, as the Coral rag, the species are more limited than usual. In others, as in the great Oolite, there are unmistakeable indications of the vicinity of land.

But, although there is no great break, there are sufficient gaps to justify the assumption of many intervals and interruptions having taken place during the accumulation of the middle Secondary rocks of England. Many deposits well developed in one place, are absent in another. In some places, as on the Dorsetshire coast, the sequence is perfect but thin. In Yorkshire the lower beds are greatly modified, and

contain remains of land plants. Everywhere the Portland rock is fragmentary. The Stonesfield slate is remarkable for its mammalian bones, but is very local. And then, lastly, the series terminates with the Purbeck and Wealden rocks, a deposit, for the most part from fresh water, thrown down at the commencement of the interval that elapsed between the middle and upper Secondary formations.

When in the lowest beds of the lower Greensand we find deposits not always unconformable in their stratification with the upper Oolites, but separated absolutely in the character of its fossils, we recognize that we have passed another of the great breaks, in succession, on which much of the sharpness of geological definitions may be said to depend. The contents of the Purbeck beds are, for the most part, unknown in the Oolites; and it has been suggested, with some show of probability, that while the true Wealden are undoubtedly delta deposits, these are lacustrine.

But there must have been a long period, not marked with any considerable disruptions or cataclysmic disturbances, between the last Oolitic and the first Cretaceous marine deposit. All had had time to change, and the accumulation of some 2000 feet of fresh-water mud and sand must have needed time, that may elsewhere have been employed in removing by denudation rocks already at the surface.

Afterwards we have the Cretaceous series wonderfully rich in fossils, chiefly in the upper part (the white chalk), but not wanting in any important department. Here there is evidence of a break of some importance. Between the lower and the upper Greensand, out of 280 species only fifty-one pass upwards from the one to the other, through the Gault. A real stratigraphical break also exists, the Gault lying unconformably over the lower Greensand, at various points round the Weald and elsewhere. There is no other important break till above the upper chalk, where we meet with that most important, most widely recognized, and most extensive of all—the great line of demarkation between Secondary and Tertiary. Only one species of Terebratula (*T. caput serpentis*), and a few Foraminifera, survived during that long period between the close of the Cretaceous and the commencement of the Eocene epochs.

Professor Ramsay, in his addresses, does not continue the discussion beyond the close of the Secondary period. In England, the indication of breaks within the Tertiary period are several and well marked, but they have not been worked out systematically, with due reference at once to stratification and change of organisms. Certainly, such a break occurred after the close of the Eocene period, the whole great series of Miocene

rocks being absent in England, and others of more recent date might be made out, but there is more continuity than interruption, in spite of enormous changes, and there has been a frequent but gradual introduction of new species, both of marine and land animals.

To sum up the result, we may thus recapitulate :—

There are between the oldest known fossiliferous rocks and the upper Silurian rocks	6	physical breaks.
In the Old Red Sandstone	1	,,
In the Carboniferous system	1	,,
Between Carboniferous and Permian .	1	,,
Between Permian and New Red Sandstone	1	,,
In the New Red Sandstone	1	,,
In the Lias	1	,,
Between the Oolitic and Cretaceous systems	1	,,
Between the lower and upper Greensand	1	,,
Between Secondary and Tertiary . .	1	,,
In the Tertiary series	1	,,

There are thus nine breaks in the Palæozoic series, four in the Secondary, and one in the Tertiary, besides the breaks between Palæozoic and Secondary, and Secondary and Tertiary respectively, making in all sixteen important physical breaks in the succession of the strata in England. The number of less important interruptions is very large; but it would be difficult to estimate them, or to decide, in the present state of knowledge, whether the facts justify the assumption of a break of the nature here described.

The conclusions to be drawn from the consideration of these facts in geology well deserve careful study. In the first place, there is the general inference, which may be given nearly in the words of Professor Ramsay, that "in cases of superposition of fossiliferous strata, in proportion as the species are more or less continuous, that is to say, as the break in the succession of life is partial or complete, so was the time that elapsed between the close of the lower and the commencement of the upper strata a shorter or a longer interval." It is important to note here, that "the break in life may be indicated not only by a difference of species, but yet more importantly by the absence of older and appearance of newer allied or unallied genera."

It results from this inference, if correct, that "strata only a few yards in thickness, or even the absence of such strata, may serve to indicate a period of time as great as that required for a considerable accumulation of fossiliferous deposits."

But again we see that a recognition of the importance due to the absence of certain links in the chain—links found perhaps elsewhere—tends to increase enormously the time, already very great, that seems to have been needed for the deposition

of the successive strata in our country; or, in other words, using once more the language of Professor Ramsay, if we assume that the causes producing physical change were the same in former times as they are now, both in kind and intensity, then, "the upheaving, contorting, and dislocation of the strata and the vast denudations they underwent before re-submergence, generally represent a period of time longer than that occupied respectively by the deposition of the formation disturbed, or of that which overlies it unconformably."

Many of the great physical breaks range widely, and might turn out to be much more extensive were we able to examine geologically the rocks beneath the sea. At all times deposits have been chiefly formed under water. At the present time this must undoubtedly be the case, and we have no reason to suppose that it was ever otherwise. Of the vast tracts of the earth either covered by water or otherwise inaccessible we know not what they might teach, but we are sure they would abound with valuable lessons. If, in some cases, they proved the break to have ranged more widely, they would in others fill up the gap. But the gaps and intervals may be wider and larger than the preserved portions. During the long interval when species were changing, water was not idle. Every modern deposit is made of material stolen from some previously deposited rock, whether in its original state or after metamorphosis, and to provide this new material there is no supply beyond what is obtained from the denudation and destruction of the older one. Who can doubt, then, that the older one may often have disappeared altogether.

In looking at the list of physical breaks, one is struck by the fact that the Palæozoic series, especially the older portion, exhibits the greatest number of important breaks. This may have something to do with the comparative poverty of such rocks in fossils. But it is not to be wondered at that these rocks, which, more than any others, have been alternately depressed and elevated, and which have been exposed to enormous pressure at great depths, and also to all other causes of change, should have undergone so great an amount of metamorphosis as to have obscured and destroyed their fossil contents; and we need not be surprised if during the vast periods needed for these operations, there has been swept away to form more modern rocks far more than has been left behind. Let the reader consider the somewhat analogous case of the Cyclopean wall of some old Greek or Etruscan city, originally constructed long before the historic period. Century after century this wall has served as a quarry from which all the stones wanted for the use of succeeding inhabitants of the neighbourhood have been drawn. The squared blocks of the first wall

have been built into the Greek temples of the second city; the fragments of the temple have helped to construct the Roman palaces of the third; the decayed palace has supplied the farm-house built in the Middle Ages, and from this house have been obtained such stones as were left to build the hut in which the goatherd now dwells. And yet, in spite of this, some of the old wall remains. We can even make out its direction and something of its ancient grand proportions. The tool-marks upon its stones represent the fossils of the rock, and point out to us the handiwork of some living organism, while the conversion of some plainly hewn stone into the shaft of a Greek column, or the step of a Roman stair, obliterating the first use, point to others more modern which might lead us to forget the past history. So it is with the old rocks; the breaks are many, and the changes are great; but the breaks and the changes themselves tell the history in so far that they prove to us a lapse of time compared with which modern history is as nothing.

And it is only in this way that it is possible to obtain a reasonable idea of the true nature of geological history. In the newest rocks, where there is no appearance of a break of any kind—in the cases where we can make the nearest approach to a record of continuous events, we find that the species characteristic of one part of a period are not those that prevail in another. Some difference of this kind is invariable, and the longer and more complete the evidence, the more clearly does this fact come out. The law of nature in this matter is clearly marked. It is a law which, in its normal action on organized matter, avoids mere repetition and tends to perpetual variety. It is the law, according to which the two sides of a man's face are not strictly alike, the strength of the two sides is different, the children of the same parents are some tall, others short, some dark, others fair. This law prevails throughout all nature—it lies at the base of all natural history; and it is connected, more or less clearly, with another great law, that of the perpetual adaptation of every part to every other, not by a monotonous uniformity, but by appointing change as the principle of action.

Nature indeed is infinitely elastic. Life is thrust in everywhere, and that which is present is always of that kind best adapted for the circumstances. But this is not effected by any after-thought of Providence, or by a miracle interfering with the ordinary course of things. It is in itself Providence fitly so called. It is the *foreseeing* and arranging beforehand that there shall be no hitch or interruption in the great work of creation.

And this great method of nature once understood, the weakness of falling back upon a succession of destructions and

re-creations of species, as the method of nature, seems to stand out strongly as an idea utterly unworthy of an Almighty and Allwise Power. Perfection requires that there should be a provision for whatever may happen. The course of nature has been found to involve alternations of greater or less regularity in the accumulation of deposits on the globe, and the conversion of them into rocks. Long periods of comparative rest have been succeeded by long periods of comparative disturbance and movement. It is highly probable, almost certain, that this alternation has always been adopted, and thus perhaps in reality it may be that the views of those geologists who would avoid, and those who would admit, cataclysmic action, will ultimately be found to agree. But it is not within our experience in any cataclysmic action that a sudden destruction of all life should be a part of the disturbance. As far as we know all disturbance is local as well as sudden, and modification of species may be so to. During repose there is little change, during disturbance there is much. In other words, animals and plants adapt themselves, or are adapted by some universal law of growth and development, and they do this gradually and slowly if the alteration of external conditions is slow, but rapidly and completely if the change is quick. But as there is always some change going on in the external inorganic world, so there is always corresponding change in the organic world; and thus species are constantly being introduced, culminating, and decaying.

To obtain a true notion of the workings of nature then, we must study the continuous formations of the Secondary period, endeavouring to judge of time by comparing changes formerly with changes now. The tables given by Professor Ramsay will enable the student to do this in some measure; but he must not suppose that he thus obtains the precise truth or all the truth. In the first place, the number of species found in different formations is always increasing by discovery and research in the field, and the proportions are, of course, subject to change. In the next place, this number is always either increasing or diminishing by the work in the closet, as the palæontologist makes or unmakes species; and this is, unhappily, a source of confusion that must long remain. Naturalists cannot agree as to what external characters are sufficient to form species, and it is almost certain that they have generally erred in admitting mere accidental varieties of form or development, and giving a specific value to such small modifications. Time probably will greatly diminish the number of species whose names must be learnt; but for the purposes of the inquiry at present before us, those marked varieties that are easily recognized and are permanent, whether they be or

be not real species, and indeed whether true species exist or not, are sufficient, and to be depended on. What is sought is a modification of external form that shall indicate a change in conditions of existence. A close resemblance of structure is proof of absence of change in conditions of existence, while a marked change of structure affords equal proof of such change.

In examining the Secondary rocks, we find alternately small and larger varieties in the proportion of species that pass from one to another. In one place we find fifty per cent. of the species common to the lower and overlying rocks; in others there are passages where most of the Ammonites, or Belemnites, or Terebratulæ, are continuous, but other shells change; or where the majority of species continue, but some of marked importance are altered. All facts of this kind are lessons, and they are the best and truest lessons afforded by modern geology. The more complete the series the more carefully can they be studied.

But when we have learnt the meaning of a small part of a small formation developed in the ordinary way in a single district, and observe the degree of change thus produced; when we find that of each hundred species, or marked varieties, of animals or plants contained in the middle of such a deposit, only about fifty come up from the formation of a similar kind immediately below, although no stratigraphical interruption can be traced, while only twenty pass into the rocks above, with equally little evidence of disturbance; we shall see that time alone is capable of inducing a great change, or, at least, that time, combined with such changes as leave no mark, has done this thing. We then see the value of time, and are able to comprehend the next step, namely, that when there is marked change in mineral condition in two rocks, one overlying the other, the difference in species is much greater. This perhaps may seem less surprising, for there may have been migration, and the old species driven away for a time may return. They do occasionally but rarely so return, but never in large numbers. Time again has acted, and time, as well as circumstances, change species.

When, finally, we come to a total difference, a true palæontological break, accompanied it may be by a stratigraphical break, so that not more than from two or three up to fifteen or twenty out of every hundred species pass from a rock below to an unconformable stratum above, we feel that the lapse of time now required must have been proportionably great. When the lower rock has evidently been not only formed but dried and hardened, and sunk down to the depth at which metamorphic change is active; when it has there been converted into a different mechanical and mineral combination,

muds having become shales or schists, limestone silicified, or the thousand other changes having occurred that are familiar to geologists in old rocks; when large sections have been denuded and pared away, and the rest is lifted up so as to incline at a great angle to the horizon, and when finally this upheaved rock has once more become an ocean-floor, the receptacle of fresh deposits in which there is no one form of life identical with those of the underlying rocks, we may trace in the break and the unconformability as good evidence of the lapse of time, as if we could count the centuries that have elapsed.

The gaps in the geology of one country are occasionally filled up in another, and thus we often have independent evidence of the lapse of time corresponding to the palæontological break. Thus, among the older rocks we find large and important series of Devonian rock containing whole groups of characteristic fossils, magnificently developed in Western and Northern Europe, but very imperfectly rendered with us. So also in the Triassic period the fossiliferous strata and even the rocks are altogether so poorly developed in England that for a long time the formation was regarded as subordinate and unimportant. And yet in this case the Continental representatives are fully as important as the Oolitic series of the same districts. Similar examples occur in the Neocomian representatives of the lower Greensand and the Miocene or middle Tertiary series. Indeed, when we approach recent times the accumulations of material in one country filling up what are apparently unimportant gaps in another, are so large and important as to justify us in attributing very long periods of time to very small differences of specific character.

Let us, with the light we now possess as to the conditions of accumulation and the physical breaks, whether biological or stratigraphical, endeavour to recapitulate very generally the succession of geological events in England. The oldest formations were probably deposited in deep seas during depression, and these deposits once formed were depressed, metamorphosed, and re-elevated again and again at a time when there was little land in the Northern hemisphere. Towards the middle part of the great Silurian period when the Llandovery rocks were deposited, the sea-bottom had become elevated, and was almost a beach. Then succeeded another period of depression. During the Devonian period there was enormous and comparatively rapid denudation—the materials washed away being of course Silurian strata, and in some places accumulations of clayey mud and sand were deposited at moderate depths, while elsewhere coarse conglomerates were rapidly heaped together. The older part of the Carboniferous series

consists of coral reefs built on a descending sea-bottom; the newer part was certainly formed near land under circumstances highly favourable, not only to the rapid and abundant growth of vegetation, but also to its equally rapid accumulation in numerous and recurring strata afterwards converted into coal.

But amongst and between the deposits thus characterized, there are huge lacunæ, marking intervals as numerous as they must have been vast. The Palæozoic rocks were thus, as far as we can judge, much longer in their preparation than the Secondary. Perhaps it would be safe to estimate that they occupied as much time for one division as did all the Secondary rocks together. And then the Secondary rocks, large in extent and thickness compared with the Tertiary in England, are very much surpassed by the latter in many parts of the Continent. It is evident that with us they have been much denuded. It may well be that the interval between any two of the ten physical breaks between the older Silurians and the Permian represents as much time as the whole of the Secondary period, from the New Red Sandstone to the Chalk; while, on the other hand, one sub-division of the Secondary series needed, perhaps, as much time to elaborate as the whole of those great Tertiary accumulations that so abound in the South of Europe, where a single bed of limestone is more prominent than all the Silurian rocks of the Continent.

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ON THE RESTING-SPORES OF CERTAIN FUNGI.

BY THE REV. M. J. BERKELEY, M.A., F.L.S.

(*With a Tinted Plate.*)

It has been well known for some time, mainly from the observations of Pringsheim, that many of the green Algæ, in addition to one or more forms of fruit destined more especially for their immediate propagation, produce certain spores, known under the name of Resting-spores, which do not germinate so readily, but after being dormant for many weeks or months, and after undergoing various modifications, give rise to a new crop in the following spring or summer.*

Nothing of this kind of provision both for present and future need was till very lately clearly ascertained amongst fungi. In the higher forms, a spawn, or mycelium, is produced by the germination of the minute spores, which in some cases is capable of spreading about and increasing without bearing fruit, perhaps for years, till circumstances arise favourable to its perfect development. The spores of many fungi are, moreover, endowed with powers of resisting drought or moisture for various periods, but though several forms of fructification are known to occur in certain species, as, for example, in the hop mildew, it could not be said of any, so far as our information reached, that it was specially destined to produce a crop in the ensuing season in contradistinction to other forms destined for the purposes of the current year. In some genera, as *Rhytisma*, the fruit does not seem to be perfected till some months after the leaves on which it grows are fallen. Fries informs us that when the young leaves of the sycamore are bursting forth, he has seen a cloud of sporidia issue from the specimens which have been lying on the ground all the winter. Cases like these, however, have nothing to do with resting-spores, which in the genera in which they are produced have their own especial end to answer beyond that of other spores.

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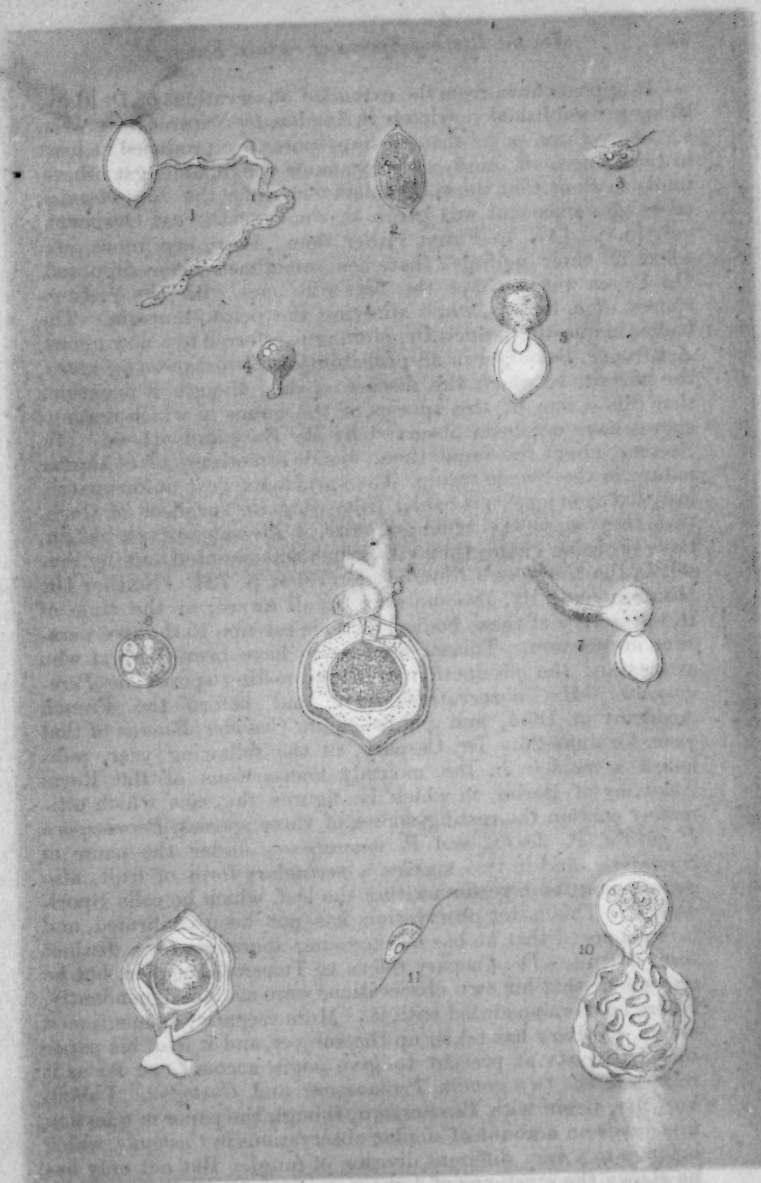
It appears now, from the extended observations of De Bary, in a paper published very lately in *Annales des Sciences Naturelles*, ser. 4, vol. xx. p. 5, that resting-spores are produced at least in two genera of fungi, a circumstance which, amongst others, tends to show that those botanists who refer the *Saprolegniæ*, of which an account was given in the INTELLECTUAL OBSERVER, vol. iii. p. 147, to Fungi rather than Algæ, are more justified in their notions than has sometimes been supposed. Dr. Payen was perhaps the first who met with the resting-spores of a fungus, while studying the potato murrain. The bodies in question, which Dr. Montagne referred to a new genus, *Artotrogus*, belonged in all probability to *Peronospora infestans*, the parasite to which the disease is due, though it is curious that this is one of the species of the genus in which resting-spores have not been observed by De Bary and others. Mr. Broome, about the same time, found something of a similar nature in the Swede turnip. The specimens were unfortunately lost, but it is most probable, from what we recollect of them, that they were the resting-spores of *Peronospora parasitica*, their probable connection with which was pointed out by myself in the *Gardener's Chronicle* for 1854, p. 724. Neither Dr. Montagne nor Mr. Broome were at all aware, at the time of the discovery of these bodies, of their relation to the two parasites in question. Tulasne appears to have been the first who ascertained the production of these resting-spores in *Peronosporæ*. His observations were laid before the French Academy in 1854, and published in *Comptes Rendus* of that year, for June 26. Dr. Caspary, in the following year, published a memoir in the monthly transactions of the Royal Academy of Berlin, in which he figures the sacs which ultimately contain the resting-spores of three species, *Peronospora Hepaticæ*, *P. densa*, and *P. macrospora*, under the name of Sporangia, and in two species a secondary form of fruit, also growing on the mycelium within the leaf, which he calls Sporidangia. This latter observation has not been confirmed, and it is supposed that he has taken young sporangia for a distinct form of fruit. Dr. Caspary refers to Tulasne's memoir, but he informs us that his own observations were made independently, before he was acquainted with it. More recently, as mentioned above, De Bary has taken up the subject, and it is of his paper that I purpose at present to give some account, so far as it relates to the two genera *Peronospora* and *Cystopus*. I shall, however, begin with *Peronospora*, though the paper in question first gives an account of similar observations in *Cystopus*, which belongs to a very different division of fungi. But not only has he shown the existence of resting-spores in most of the species belonging to the two genera, but he has given details of the



Resting Spores of Fungi.

occurrence of antheridia in the same genera, closely resembling those which were lately described in the INTELLECTUAL OBSERVER, in the paper on "Egg Parasites;" and in most of the species; though not in *Peronospora infestans*, the existence of little suckers on the threads of the mycelium, which perform apparently a material part in the imbibition of the juices of the mother plant.

As *Peronospora parasitica* is a species which is to be met with in every parish, if not on cabbages and turnip leaves, at least on the common shepherd's purse, *Capsella bursa pastoris*, where it frequently accompanies *Cystopus candidus*, which also has its resting-spores, though very differently sculptured, I purpose to reproduce more especially the illustrations of that species.

The mycelium of the *Peronosporæ* runs freely amongst the tissues of the leaves of the plants on which the species are parasitic, especially the loose tissue of the under surface, either forcing its way between the cells when they are in close contact, traversing the intercellular cavities, or actually penetrating the cell-walls. The mycelium throws up erect threads through the stomates of the leaves, which, when they become free in the open air, are more or less branched. They are sometimes repeatedly forked, as in *Peronospora viticola*, Berk. and Curt., undoubtedly the most highly developed species of the genus, sometimes merely divided above for the purpose of bearing the acrospores or conidia, as in *Peronospora curta*, Berk. and Br., a species evidently identical with *P. pygmæa*, De Bary. These threads are in general even, but in *Peronospora infestans* they are swollen at intervals. The ultimate divisions, which are straight or uncinate, bear more or less elliptic or obovate spores (acrospores), with or without a terminal papilla.

The acrospores propagate the parasite in different ways. When placed upon a drop of water, or in a moist atmosphere, they push out, a few hours after they are sown, from the apex, or from some indifferent point, as in *P. parasitica* (Fig. 1), a thread, much after the manner of the spores of many Sphæriæ; and if it be the proper season for the growth of these parasites, temperature and time seem to be of little or no consequence. In the lettuce mould, *P. gangliformis*, Berk., the germination invariably takes place at the terminal papilla.

In some species, however, as the yellow rattle mould, *P. densa*, and the anemone mould, *P. curta*, the protoplasm of the spores first exhibits a number of globose cavities (vacuoles). After a time, the whole mass oozes out from the apex (Figs. 5—7), where it assumes a globular form, and becomes invested with a membrane. Soon after, it gives off a thick tube from the point opposite to that at which it at first protruded. This

mode of germination takes place only when the spores are entirely immersed in water, and in *P. curta* the exclusion of light is a necessary condition. The germination takes place consequently, in most cases, at night, a few hours after the spores are sown.

In *P. umbelliferarum*, and the potato mould, *P. infestans*, if the spores are placed in water, the protoplasm, in the course of a few hours, is divided by delicate lines into distinct portions, in the centre of each of which there is a vacuole (Fig. 2). The papilla soon vanishes, and after a time the several portions are expelled in the form of perfect zoospores, each of which moves about, when in water, by means of two lash-like threads (Fig. 3). The number of these zoospores varies from six to sixteen in *P. infestans*, and from six to fourteen in *P. umbelliferarum*. The movement of these zoospores ceases in from fifteen to twenty minutes; each then becomes invested with a membrane, and pushes out a curved, subflexuous, rarely branched thread. Occasionally a second is protruded from the opposite side. In the potato mould the exclusion of light seems more needful than in *P. umbelliferarum*.

In *P. infestans*, the spores, when sown on a moist substance, put out a simple tube, whose apex swells into an oval, frequently unsymmetrical vesicle, attracting gradually all the protoplasm, and becoming isolated from the mother cell by a partition. This secondary cell may generate a third, and all alike, when plunged in water, are capable of generating the zoospores. A third mode of germination in this species, like that of ordinary spores, occurs occasionally at the apex. The conditions under which the several forms of germination take place, are at present doubtful. Extended observations can alone show whether peculiar forms of germination or of the development of the acrospores are restricted to certain species.

In every case these spores are capable of germination or further development the moment they arrive at maturity; and, if not allowed to become too dry, they may retain their vitality for some days, or even weeks. When germinating upon a plate of glass, their mycelium soon dies; but if on a leaf belonging to the particular plant on which the mould is an habitual parasite, or that of some closely allied species or genus, it soon penetrates the leaf, the entering portion becoming at once more or less swollen. The presence of stomates is in general a matter of indifference, though, in some cases, and especially in *P. infestans*, the germinating threads avail themselves of the ready aperture of the stomates, notwithstanding their ability to pierce the cuticle.

In *P. umbelliferarum*, the germinating thread enters only by the stomates. Fresh spores are formed in about a week or fort-

night. When spores are sown on the leaf of some plant on which they are not habitually parasites, they comport themselves very much in the same manner as if they had been sown on glass.

In general, all parts of the mother plant above the surface of the soil are indifferent. The potato murrain, however, attacks the tubers, the germinating threads easily penetrating even their thick cuticle. It is easy to conceive how the zoospores can be washed down to them after heavy rains. In *P. umbelliferarum* a stomatiferous surface is a necessity.

The threads of the mycelium within the leaf, meanwhile, are not inactive. They are generally more or less branched, sometimes forming at intervals tufts of thread, and very irregular in outline. They produce on short lateral peduncles globose bodies, which are destined ultimately to give rise to the resting-spores. The metamorphosis of their protoplasm, which is either grumous or filled with distinct definite globules, does not take place, if De Bary's observations are correct, without the help of antheridia, which are produced either by the side of the sporangia, or on neighbouring laterals. They are obtuse, shortly pedunculate, and either regular or irregular in form, sub-globose, or more or less clavate. After they have come in contact with the sporangia, which like themselves are at length separated by a partition from the protoplasm of the mycelium, they push out a little tube which penetrates their walls, making its way towards the centre, till it comes in contact with the young resting-spore (Fig. 8), very much in the way in which the antheridia act in *Saprolegniæ*. Various changes then take place in the protoplasm; a central mass is formed, the outer space being filled with large globular bodies exactly similar to those which occur in *Botrytis Tilletii* and *Polyactis;* the young resting-spore soon acquires a membrane which either remains even to the end, or becomes reticulated or variously sculptured (Fig. 9). The surrounding cavity exhibits numerous vacuoles, and the outer coat of the resting-spore is thickened, probably at the expense of the protoplasm, which was not consumed in the formation of the spore. If the spore is now macerated, the outer reticulated coat vanishes entirely, leaving a perfectly even, globose body, with two distinct membranes and the remains of the fecundating tube still attached. Dr. Caspary, as appears from his figures, evidently saw something of the antheridia, though he does not appear to have suspected their nature. The most perfect series of observations which De Bary has made are in the chickweed mould, *P. alsinearum*, a species which has not hitherto been gathered in Great Britain, but which in all probability could be found by any one who looked out for it.

Unfortunately, the further development of these resting-

spores has not been observed. The whole process, however, of their formation in the genus *Cystopus* is so precisely similar, that we cannot err greatly in assuming that it must be much the same in the two genera.

The genus *Cystopus* comprises those parasitic fungi amongst the Uredines, which are remarkable for their white spores, Till the resting-spores of the different species were ascertained. it was almost impossible to find good distinctive characters. One species at least, *Cystopus candidus*, is to be found everywhere on the common shepherd's purse, where it is often accompanied by *Peronospora parasitica*. It is also frequent on turnip leaves, cabbages, and other Cruciferæ. The acrospores, or conidia, which spring from the swollen threads of the mycelium, form necklaces, as in *Oidium*, the joints of which give rise to zoospores, as first observed by Prevost, in 1807. Like those of *Peronospora*, they move about in water by means of two lash-like appendages. Like them also, they germinate when placed in water, and when resting on the leaves they make their way by means of a germinating thread into the subjacent tissues, which, as in most *Peronosporæ*, throws out little suckers. The branched mycelium gives off sporangia and antheridia, exactly as in *Peronospora*. It is needless, therefore, to dwell at length on this matter. When ripe, the sporangia are strong warted.

They fall down, doubtless, with the leaves upon the ground, where they remain till a fitting season arrives for their development. When sown artificially, they do not show any change till after the lapse of some months. Those gathered in June did not make any further progress till December. If leaves containing sporangia, after being kept for some time, are immersed in water, the surrounding tissues disappear, and the sporangia are set at liberty. If placed at once in water, moulds are often developed, and a species of *Chytridium*, so that it becomes difficult to follow out the development.

The epispore bursts irregularly, and the contents are discharged still surrounded by the endospore, and exhibiting one or two vacuoles (Fig. 10). The mass of protoplasm then contracts towards the centre, is divided by delicate lines, as in the acrospores of the potato mould, each containing a vacuole; these gradually become zoospores, which are soon discharged, and closely resemble those produced from the conidia.

We have, then, not only in *Saprolegniæ*, but in undoubted fungi, distinct antheridia. It is true that active spermatozoids have in no case been observed in the antheridia, but the whole mode of development is so exactly similar to what takes place in *Saprolegniæ* that we cannot doubt that they are really what De Bary considers them; and, if Phænogams do not produce

Spermatozoids, a similar condition may obtain in these antheridia. The provision made for the rapid development of these parasites and for the preservation of species is truly marvellous, and sufficiently accounts for the difficulty of extermination, and their apparently sudden dispersion, especially in wet weather. Besides, wherever any portion of an infected plant outlives the winter, there is a stock of mycelium, ready to throw out fresh fertile shoots.

Almost every good author now ascribes the potato murrain to the attacks of the *Peronospora*, and I am glad to see that De Bary is decidedly of the number who do so. It is plain, too, since these moulds are capable of being developed on healthy plants, that they are true parasites, and not the mere consequence of previous disease.

DESCRIPTION OF THE FIGURES.

1. Acrospore of *Peronospora parasitica*, germinating on glass in a moist atmosphere.

2. Acrospore of *Peronospora infestans*, producing septa in the midst of its protoplasm, each division containing a vacuole.

3. Zoospore, from the same.

4. Zoospore, from the same, germinating.

5. Acrospore of *Peronospora densa*, with its protoplasm oozing out.

6. Ejected mass, acquiring a membrane and showing vacuoles.

7. Mass germinating.

8. Young sporangium and antherid of *P. parasitica*.

9. Sporangium, containing a perfect resting-spore.

10. Resting-spore of *Cystopus candidus*, ejecting its contents, which are in the course of producing zoospores.

11. One of the zoospores. In *Peronospora infestans* the two lash-like appendages spring according to De Bary from the same point in the border of the vacuole; in *Cystopus* and most *Peronosporæ* from opposite sides of the border.

All the figures are more or less magnified.

BROWNING'S NEW ANEROID BAROMETER.

A NEW aneroid, by Mr. Browning, was exhibited at several of the scientific soirées of the season, and briefly noticed in the last number of the INTELLECTUAL OBSERVER. It was constructed with a view to two important qualities: great susceptibility to atmospheric changes of pressure, and power of making small variations strikingly visible to the eye. We shall endeavour to show how these requirements have been fulfilled, and in order that those to whom the subject is new, may follow our descriptions, we shall begin by considering what an *aneroid* barometer is. The term *aneroid* literally means deprived of air, and we might substitute for it the phrase, "vacuum chamber barometer." But neither the original name, nor its English version, indicates the peculiarity of the kind of instrument to which it is applied. Water barometers, mercurial barometers, and so-called aneroids, all of them have vacuum chambers, more or less complete in their freedom from air. To make a water barometer, a quantity of that fluid is boiled until its air is expelled, and a tube, closed at the top and about thirty-five feet long, is filled with it. The lower end of the tube is immersed in a cistern of water. Now the air presses upon the water in the open cistern with a force of fifteen pounds per square inch; but it cannot press upon the water at the top of the *closed* tube—all its pressure in that direction being intercepted by the tube itself. Thus the water in the long tube falls until it exactly counterpoises the air pressure on the open surface of the cistern. In round numbers this takes place when the water column in the closed tube is thirty-four feet high. But the tube, according to our supposition, was thirty-five feet high, so that when the water has fallen one foot, it has left a vacuum chamber in the upper part; not, however, a true and perfect vacuum, because there will be a little vapour in it. Mercury is so much heavier than water that one inch of it balances about thirteen and a-half inches of water. From this it arises that by substituting mercury for water, we can make a barometer with a much shorter tube. We can, for example, fill with mercury a tube, closed at the top, as in the preceding case, but thirty-four inches long, and having immersed the open end in an open cistern containing mercury, the column in the tube will fall until its weight balances the atmospheric pressure, and the space above the mercury in the tube will be a vacuum chamber much more perfect than when water was employed. In either case if the air grows heavier, the

fluid in the open cistern will have to bear more weight and a portion of it will be shoved up into the vacuum chamber, causing the column of water, or mercury, as the case may be, to rise in the tube. If the air grows lighter, the pressure on the cistern will be less, and a corresponding portion of the fluid will fall out of the tube into the cistern until a balance is obtained.

That which is necessary to this kind of barometer is a vacuum chamber in which a fluid can rise or fall. The vacuum chamber is formed of glass on all sides but one, and that side is formed by the fluid, which contracts the chamber by rising, and enlarges it by falling. If, therefore, we have a vacuum chamber that permits one or more of its sides to rise and fall as the pressure upon it changes, we may employ it as a barometer, whatever may be its form or construction; but some forms and some constructions will be much more sensitive than others. Suppose we tied a bladder over the mouth of a tumbler and then exhausted part of the air, we should find the bladder pressed down in the middle. If we put the tumbler so arranged under an air-pump and began to exhaust the air, the bladder would begin to rise. The air inside the tumbler being elastic, would occupy more and more space as the pressure upon it was reduced. Thus, in a rough way, and only capable of showing considerable changes, we should have made a barometer out of a tumbler and a bladder.

Suppose that, desiring more accuracy, we constructed a flat cylindrical chamber of thin elastic metal, and then exhausted nearly all the air. Here we should have a more sensitive instrument; but it would vary so little in its dimensions under such changes of pressure as take place at the earth's surface, that we should not be able to see that any variation occurred. We, therefore, must go a step further. In the first place, we may fix our little vacuum chamber by the centre of its lower surface to a firm stand, then we may attach a spring to the upper surface, which counteracts a certain portion of the atmospheric pressure. The air with all its weight presses the chamber so as to make it collapse. The small quantity of air left in the chamber, by its elasticity does a little to enable the walls of the chamber to resist the air's force, and the spring exercises a stronger action of the same kind. The result is, that when the air has produced a certain amount of collapse, a balance is obtained. That is to say, when the spring has been stretched to a certain point, and the minute quantity of air inside the chamber has been compressed to a certain extent, the air pressure has done its work. Under these circumstances, a little more air pressure produces a little more collapse, and a little less air pressure allows the spring and

the small portion of elastic air left in the chamber to lessen the amount of collapse that has been produced.

Here then we have a sensitive instrument, but its movements of expansion and collapse are too small to be seen; but anybody who has handled a long-bladed pair of scissors can understand how we may make a very minute change visible at a glance. A slight motion of the handles of the scissors—which are near the pivot, or fulcrum—induces a large amount of motion at the ends of the blades. If, therefore, the minute motion of the walls of our vacuum chamber can be communicated to the short leg of a lever, which has a long leg on the other side of the fulcrum, the extremity of the long leg will move a great deal, while the short leg traverses a very small space.

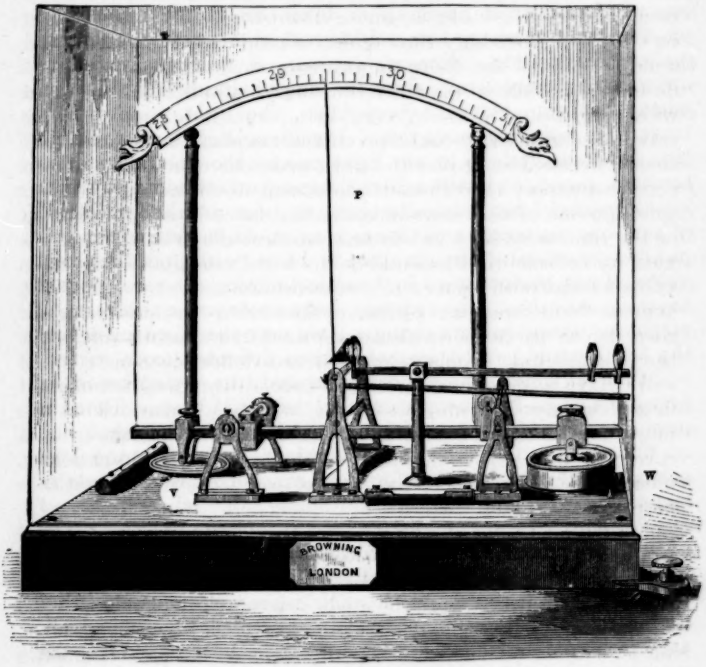
It is not necessary that we should explain the details of aneroid construction, if we have made the principle clear. In good aneroids the chamber is formed of thin elastic corrugated metal, and is usually about the size of a crown piece. If such an instrument is carried up a high mountain, the actual movement of the chamber walls will not, perhaps, exceed one hundredth of an inch, or the thickness of a sheet of common writing paper. By the lever contrivance this is multiplied so as to carry an index hand over a considerable arc of a circle: it may be of six or eight inches diameter.

We have now arrived at a pretty accurate conception of an aneroid, as usually made, whether it has the dimensions of a stout silver watch, or is as big as a moderate sized clock.

Let us now suppose that, instead of such instruments as we have described, and which are portable, it is required to make an extremely delicate stationary aneroid, capable of responding to every fluctuation of atmospheric pressure, with a sensitiveness not possible in instruments that are made to withstand the shaking incidental to carrying them about, and which shall indicate, and, if needs be, register, changes that must be exhibited on a large scale if they are to be seen at all. Mr. Browning set himself the difficult task of contriving an aneroid to meet these wants, and the result is the exquisite instrument represented in the annexed drawing.

In the first place he did away with the spring. We have seen that its function is to counterpoise a certain weight. Now, although a spring will balance a given weight, it is obvious that one weight may be made to balance another. Accordingly, Mr. Browning made his aneroid upon the principle of a steelyard. At one end of a beam, suspended like that of a fine chemical balance, so as to turn with the greatest nicety, he fixes a weight (w). The beam is suspended like a steelyard beam, not from its centre but much nearer one end. The short end

of the beam is fastened to the upper wall of the vacuum chamber (v), and when the air tries to make the chamber collapse by pressing upon it with a given force, the weight at the long end of the beam is an exact counterpoise. If the air pressure exceeds this quantity, the weight is raised to a proportionate extent. If the air pressure is lessened, down goes the weight, just as the weight attached to the steelyard goes down, if after having balanced a leg of mutton we take off a slice.



BROWNING'S NEW ANEROID.

Of course the motions are very small, but they are magnified by levers, as shown in the drawing, and cause an aluminium pointer (P) to traverse a considerable arc.

If it is desired to exhibit the minute oscillations of the vacuum chamber's walls on a very large scale, it becomes practically necessary that the hand which has to move over a wide arc should be extremely light, and in addition to the slender metallic pointer which will move over three or four inches when the walls of the chamber have moved through

one hundredth of inch, Mr. Browning has provided us with another hand several feet long *which weighs nothing at all.* This hand he makes out of a beam of light! He did not invent these imponderable pointers, which were previously used in other instruments, but he has applied them to his new aneroids. If any reader who has a steelyard, puts a little bit of looking-glass on the beam near the fulcrum, and lets the sunlight fall upon the mirror, he may throw a line of light on the wall of the room, a yard or two off, and when his scale beam moves ever so little, up or down will go the light beam on the wall, marking the oscillations on a greatly enlarged scale. This is Mr. Browning's plan. A mirror, situated as described, receives rays from a lamp suitably placed, and when the beam moves a very little, the light pointer may traverse a scale of several feet. If self-registry is required, all that is necessary is to let the light make its own autograph on sensitive paper, as in the self-registering instruments at Kew.

Only one of the new aneroids has been finished and tried at the time we write, and it has performed too many peregrinations to scientific assemblies, to have permitted the exact value of its performance to be ascertained. A good pocket aneroid will beat an ordinary barometer in quickness of response to atmospheric changes; we may therefore infer that the new aneroid (which is much more delicately constructed) will at least equal, and probably exceed, the sensitiveness of first-class large barometers on the mercurial plan. That the new aneroid is *very sensitive,* is certain; but prolonged and careful trials under the same circumstances with the best mercurials is necessary, before an exact comparative statement can be made.

We hope to see the new aneroid in public institutions and in private houses. For the former it will be of great value, as if suitably placed and protected from the tremors incident to wooden floors, it can enable a whole room full of people to see ts indications without moving from their places. This advantage will be obvious to Lloyds, and other establishments where weather changes are anxiously watched.

We confidently expect the new aneroid will prove to be the best instrument yet constructed, for making noticeable, and registering, the oscillations of the atmosphere during storms, and enabling us to see the rate at which the form of the air waves traverse a given place. When such wave forms pass over us, we are at one time under their crests, and at another under their troughs, and the rate at which such changes take place it would be very interesting and useful to know.

KUHLMANN ON CRYSTALLIZATIONS.

THE principal facts and statements contained in M. Fred. Kuhlmann's paper recently read before the Academy of Sciences, are as follows: The author commences by observing that at the moment of the formation of certain bodies, through the agency of chemical action, they are particularly disposed to assume a crystalline structure, and especially so when their origin has been due to a current of gas. Oxydes of antimony give beautiful needles when acted upon by sulphide of hydrogen at a high temperature, and oligist iron, under the same circumstances, affords a sulphide of iron having the natural lustre and aspect. Even oxyde of zinc can be transformed at a sufficient temperature into a white sulphide, crystallized in broad shining plates. Chloride and carbonate of thallium, under the influence of a sulphide of hydrogen current, yielded at first pseudo-morphic crystals, which, on being sublimed at a higher temperature, afforded the true forms.

Substituting fluoric acid gas for sulphide and chloride of hydrogen, he obtained fluorides of several metals; but he did not get the fluoride of iron in a crystalline state. Generally speaking, when crystalline minerals are formed by the reaction of gases, their forms are pseudo-morphic; but at higher temperatures many of the crystals modify their form, and this modification, observes M. Kuhlmann, "proceeds from a natural attractive force which gives to the bodies new forms similar to those which they have in nature."

In studying the crystallization of pastes composed of amorphous silicon, M. Kuhlmann met with numerous instances in which the molecules of bodies already solidified, had a tendency to further movements and the assumption of the crystalline form. The presence of water, heat, or mere vibrations facilitated this change.

The tendency of molecules of the same nature to combine when their mobility is augmented by solution or liquefaction, he considers to explain the magnificent crystals of sulphate of lime that often occur in plastic clays, or of different silicates in glass kept for some time in a state of fusion; but when minute crystals imbibe water, and transform themselves into large crystals of great hardness, he thinks it necessary to ascribe to the solid particles a tendency to approach each other in certain directions. He found this phenomenon strikingly exhibited in the deposits of sulphate of barytes near Philippville, in Belgium, and in carbonate of lime in the grotto of Adelsberg in Illyria. In the latter case, the microscopic crystals impregnated with water formed, in the first

instance, concentric crystalline layers; but the concentric lines, marking a succession of deposits, soon disappeared, and left crystalline transparent masses whose cleavage was not affected by the concentric layers: or rhombohedral figures seemed to spring from the surface.

If the solid molecules are not maintained in a condition of moisture, the crystallogenic force is counteracted, and bodies of little cohesion and no characteristic form is the result.

In calcareous or silicious pastes, moistened with water, diversely coloured by metallic oxydes or bituminous matters, certain separations may occur, and the mass may be traversed by crystalline veins of uncoloured calc or silicious spar; hence arise agates, jaspers, etc. In general the veinage of stones may be considered as likely to have resulted from internal movements, and not necessarily to have been occasioned by accidental ruptures and subsequent infiltrations.

After referring to other cases of an analogous nature to those just mentioned, M. Kuhlmann inquires whether the tendency of microscopic crystals in a sufficiently moist state to solder themselves together in larger crystals, may not throw a light on the formation of glaciers. The great masses of ice have, for their point of departure from the uncrystalline state, microscopic crystals, which a certain degree of moisture permits to unite when they descend from the regions of perpetual frost.

AIDS TO MICROSCOPIC INQUIRY.

Considerations from Physics.

Notwithstanding the many excellent works on the microscope and its management, and on the various branches of natural history which that instrument is specially calculated to elucidate, we find that young students and families still require further aid, and we therefore propose to publish a series of articles, written for the express purpose of removing difficulties which numerous communications from all parts of the country prove to exist, and in many cases to oppose a very serious obstacle to a delightful and instructive pursuit. In following out this plan, we must of necessity deal with the elements of many sciences with which a great body of our readers will be familiar; but while we thus address a portion of our pages to beginners, we shall not fail to provide our more erudite subscribers—as we have hitherto done—with a succession of papers embodying the most recent discoveries, and presenting science in its highest forms.

Without intending to supply a treatise on physics, we shall commence by adverting to a few considerations, founded on physical laws, which are necessary to be entertained before the various phenomena exhibited under the microscope, by organic bodies, can be rightly understood.

All the creatures inhabiting our globe are, in the first place, under the dominion of gravitation. Every particle of which they are composed gravitates toward the centre of the globe, with a force proportioned to the quantity of matter it contains. The pound of feathers, the still bulkier pound of air; the pound of flesh, the still denser pound of bone, etc., tend downwards with precisely the same force. Each substance has its own specific gravity; that is to say, a square inch, or any other given mass of it, weighs a certain and constant weight. If put into water it displaces its own bulk of that fluid, and the quantity of water thus displaced by a given weight of any material will depend upon the density of the substance employed. If, for example, we forced an ounce of air into a cask of wine, and allowed an equal bulk of wine to run out, the quantity of the latter would be considerable; while an ounce of gold thrown into the cask would only displace an insignificant drop. "A cubic inch of water weighs 814·75 times as much as a cubic inch of air; both being at the temperature of 60°, and under a pressure measured by a column of 30 inches of quicksilver whose temperature is 32°."*

It is obvious that the higher the specific gravity of an organism, the greater will be the exertion required to move any given bulk of it. The muscular power which enables a man to move his own body in walking or running would be quite inadequate to his locomotion if his solids and fluids weighed on the average as much as platina or gold. Thus the muscular power of any creature intended to walk, to crawl, or to swim, must be proportioned to the specific gravity of its components, and to the resistance afforded by the medium in which it is to live. A human body will float in water so long as the chest is distended with air, and drowning usually occurs because the sufferers have not learned how to balance themselves in the fluid so as to keep their heads above the liquid level. If a man were made as big as a whale and extended over seventy feet of earth, he would be perfectly helpless, because his strength would be disproportioned to his bulk. His two legs could make nothing of such a mass; but give him the whale's ability to live in water, and provide for respiration by coming to the surface at short intervals, and his condition

* *Apjohn Manual of the Metalloids*, p. 192.

would be improved, because the water would buoy him up, leaving much less for his muscular power to do. When a creature lives in water so much of its weight is practically taken away, that a comparatively small muscular force will move it. A man feels this effect when he moves a submerged stone, and the diver can carry in his arms, under water, masses that he could not possibly lift into the air.

But as water is denser than air, it requires more force to move a given bulk through it, the shape being the same. In moving any substance through a resisting medium, the form is extremely important. A thin sheet of paper may be moved edgewise through the air, with facility and safety; but, if held so that its broad surface receives the full shock, the force required to push it on will be much greater, and it will be torn to pieces in the struggle.

The preceding facts are known to every one of ordinary education, and we only mention them in order to suggest a train of thought having reference to microscopic pursuits. The microscopist examines animals, and in some cases vegetables that indulge in locomotion, and he should reflect upon the amount of force required for this purpose. He should moreover consider the two classes of resistance to be overcome—the one arising from the weight of the thing moved, and the other from the resistance of the medium through which its motion is performed. Large animals are so much heavier than air, that as we never see it lift them, we are apt to forget the *pressure in all directions* which that fluid exerts. A balloon filled with light gas is forced up by the weight of the air all around it, just as a cork introduced below water is forced up to the surface. In practical mechanics we have to deal with stiff materials, and we employ cranks and such like means to make a force turn round the corner, and do work at right angles to the direction in which we primarily exert it. The fluid is its own crank, and the perpendicular pressure of the air on each side of a balloon is turned into an ascending pressure below it, shoving it up. Water acts in just the same way. According to fluid laws, pressure is as depth, and at any given depth, equal in all directions. The air presses on the earth's surface with a force or weight nearly equal to fifteen pounds per square inch. We are unconscious of this force, because it acts in all directions, and the walls of our cavities are not forced in because those cavities contain air that has just as much tendency to force them out; or because they contain fluids still more capable than air of resisting the pressure to which they are exposed. When a cavity of any kind does not communicate freely with the air or other fluid outside it, an increase of pressure is instantly felt, and if a fish be rapidly

subjected to a great augmentation of water-pressure its air-bladder will burst.

The weight of large animals is so great in proportion to their bulk, that ordinary atmospheric currents do not move them, and have no tendency to tear them to pieces; but small insects can almost float in air, the gossamer spider needs only his silk thread for his balloon or parachute, and minute germs of life constructed of delicate materials can remain for an indefinite time the inhabitants of the atmosphere and the sport of its winds.

We have spoken of the effect of water in sustaining or balancing weight to a much greater extent than air, and the microscopist meets with thousands of instances in which this principle is applied in nature's work. Look in that pond, the delicate branches of the myriophyllum are spread out in graceful forms. You take the plant out of the dense water into the light air, its spreading beauties have collapsed, and you see only a mass of entangled green thread. In the water the plant's light branches floated; in the air they fall. The influence of flotation is beautifully shown in the jelly-fish common on all coasts. In the water the long tentacles are sufficiently sustained to enable the muscular power of the animal to employ them as its wants require; but the moment it is uplifted in the air they all fall together as a helpless and inert mass.

This sustaining power enables whales and other sea monsters to support their cumbrous forms, and it also enables minute and delicate structures, too light and too thin for atmospheric life, to preserve the shape and capacity for motion on which their existence depends. The waters of the ocean keep up the gigantic sea-weeds that rise like forest trees from the shallows of tropical coasts, and they also keep up the fine tufts of the Plumularia or other compound polyps, whose delicate shrub-like abodes decorate marine rocks and pools. In the water the Vorticellids can stand erect, elevate or depress themselves at will. In the air they would require for the same performances greater strength of material and more muscular force.

When water is still, its power of sustaining weight may be employed, as we have seen, in relieving delicate structures of a strain that would be too much for them; but when in motion it beats against obstacles—as other bodies do—with a force compounded of its velocity and its weight. An air storm may snap trees asunder, tear off the roofs of buildings and overthrow high walls, but from the lightness of air, the highest velocity which its currents are known to assume, fails to give it the momentum requisite for carrying along the huge masses of stone and rock which a rapid water torrent sweeps away in its

course. The force exerted by water currents, which is considerable at low velocities, determines the kind of organism that can live in certain situations. In ponds which are only rippled on the surface, and in streams that flow quickly, the conditions are so different, that if similar creatures are found in both of them, it is because, like the caddis worms who build their houses heavy or light, they can accommodate themselves to circumstances of different kinds. Still, or gently moving waters afford the conditions most favourable to delicate and minute forms of life; but the torrent should not be neglected, as it often rushes over stones to which Confervæ cling, and in the shelter of such friendly vegetation even feeble organisms may dwell in peace, and enjoy the large supply of air that foaming water contains.

The strength of a body depends on the cohesion of its particles, and still more on their arrangement and position. In tall objects like towers, factory chimneys, or trees, the breadth or thickness sufficient for one of fifty feet elevation will not suffice for another of a hundred, and in a horizontal beam the thickness that will give strength with a projection of ten feet from the point of support, will not do for twenty. Nor is it sufficient that the thickness should increase in simple proportion to the height or length. It must increase much quicker, or the object will break down. Every solid substance can sustain a certain limited weight of its own substance, or of another solid, without being crushed. The bottom bricks of a wall sustain those above; the bottom layers of a tree-trunk sustain those above. If the superimposed weight is too much, the base gives way. These facts prescribe limits, not only to the height of organized bodies, but also to their length, and that of their limbs. A long earth-worm could not be constructed of the soft material of many infusoria without breaking himself every time he moved; and many elegant aquatic worms are able to enjoy their lives, notwithstanding the extreme delicacy of their bodies, because the fluid in which they dwell sustains their weight, and lessens the friction with which they glide over other bodies.

In the hydra or polyp, so common in our ponds, we notice that when the creature pleases he can extend his arms many times the length of his body, and still use them with effect; but if we could put out an arm twelve feet long, it would be a poor implement, because muscular strength, strength of material, and the conditions under which it was employed, would not be in harmony with each other.

Ciliary motion affords a beautiful illustration of mechanical principles. In the first place, the shape of each cilium is such as to cut readily through the water; and, in the second place,

it appears to be an elastic body, as, when viewed under high magnification, a wave-motion may be traced throughout its length. Let the reader experiment with two sticks, each a yard long, one stiff, the other elastic, and he will find how much easier it is to give the elastic one a great velocity at the extremity furthest from his hand. The well-known instrument called a "life-preserver" owes to the elasticity of its stem much of the force with which its knob can be made to fall.

There are few principles of construction employed by man that are not found exemplified in objects which the microscopist will be able to study. Arched forms are abundant in the animal and vegetable world. The Melicerta,* one of our most interesting rotifers, makes her own bricks, and builds a round tower. The corrugated or fluted arrangement is found in many stems of plants, and in one of the moon-shaped desmids; while the shells of many foraminifera display the advantages of ribs in giving strength.

The so-called *teeth* of the *Prorodon teres*, and certain other infusoria, appear, when examined with sufficient power and good illumination, to be merely a corrugated arrangement of some stiff material, the precise use of which has not been ascertained.

The action of the so-called mechanical powers should always be noticed in living objects, many of which possess remarkable tools. By employing levers two different purposes may be served. If a crowbar is put under a heavy stone, and rested on a fulcrum near it, when the end furthest from the stone has descended several feet, the stone may be raised an inch or two. In this case, by moving the hand of the man who holds the crowbar through a *large space*, the weight to be lifted is moved through a *small one*, and the gain in power is proportioned to the loss in time. That is to say, the hand moving with a certain velocity, *could* traverse the small space through which the stone moves much quicker than it *does* traverse the larger space through which it passes, and carries with it the extremity of the lever's long arm. Here the lever is made the means of lifting a weight greater than the same force could have moved had it been directly applied. There is a loss of time, and a gain of power. But when a boatman makes a fulcrum of one of his rowlocks, and by moving his hand and one end of the oar through a *small space*, causes the other end of the oar to move through a *much larger space in the same time*, the force with which the extremity of the oar strikes the water would not move a weight equal to that which the hand could have moved if directly exerted upon it. In the first case, the hand moved through a large space, while the short arm of the lever moved through a little one; and, in the second case, the

* See *Marvels of Pond Life*. Groombridge and Sons.

hand moved through a small space, and the long end of the lever through a larger one. Gain of power took place in the one, and loss of it in the other, if such phraseology can be allowed.

It is customary to speak of gaining or losing power by employing levers; but our readers will understand that there is not, strictly speaking, any loss or any gain, but simply a different mode of distributing power. Lever action is best illustrated by a steel-yard, in which one pound, four inches from the point of support, will balance four pounds one inch from it on the other side of the support. As much work is done when four pounds are moved one inch, as when one pound is moved four inches. All that the lever accomplishes is to enable us to make practical equations of this sort.

Suppose the steel-yard, balanced by the two weights, one pound and four pounds, arranged as above stated. It will be plain that if a slight addition is made to either weight the balance will be disturbed. If added to the pound weight, it will cause it to descend through a large space to make the heavier weight rise through a little one. If added to the four-pound weight, it will enable it, by traversing a small space, to make the lighter weight move through a larger one in the same time. Now, in Animal Mechanics, it constantly happens that a small muscular contraction moves a long limb or a long jaw; and if the extremity of the limb or jaw is moved with much power, it is evident that the muscular force exercised at such a disadvantage must have been intense. Many microscopic creatures are sufficiently transparent to enable the contraction of their muscles to be distinctly seen, and the effect thereof noticed.

In all cases of lever motion of limbs or jaws of microscopic creatures, the position of the fulcrum and of the force should be noted; and if, as is often the case, the lever is a long one, and overcomes considerable resistance, we gain an insight into the strength of its material, as well as into the amount of muscular force employed. The principle of the lever will explain why it is easier to carry a long pole by the middle than by either end; and it is curious to watch how insects, and other creatures who have burdens to carry, find out by instinct or experiment how to hold them, so as not to suffer from an erroneous disposition of the weight.

Wedges of various shapes occur in the mandibles and stings of insects; and as saws and rasps are only modifications of the wedge, the palates of mollusca afford another interesting set of illustrations; and there is likewise a very conspicuous one in the elaborate saw of the saw-fly. Even the screw may be traced in its use as a holdfast; as a snail may be said to screw himself into the whorls of his shell, and thus obtain a hold which enables him to drag it about.

MR. BROOKE ON DEEP OBJECTIVES.

We have received the following from Charles Brooke, Esq., F.R.S., President Microscopic Society London:—

"My attention has recently been directed to some remarks contained in p. 329 of your June number, alleging a discrepancy between a statement of mine, contained in my report on the microscopes in the late International Exhibition, that 'no objective yet manufactured for sale at all rivals in its power of development the $\frac{1}{25}$th of Messrs. Powell and Lealand;' and another statement, contained in my presidential address, delivered at the last annual meeting, that 'I have not hitherto succeeded in developing any point of organic structure with Powell's $\frac{1}{25}$th that is not equally visible with a $\frac{1}{12}$th by Ross.' This apparent contradiction has no real existence, inasmuch as the $\frac{1}{12}$th by Ross to which I alluded (a great improvement on any previously made by him) *was not in existence* at the time to which the former observation refers; and in corroboration of my own opinion I may further state, that after having successively examined, together with Dr. Beale, with this $\frac{1}{12}$th, and with his own $\frac{1}{25}$th (or $\frac{1}{26}$th), several difficult preparations of tissue, with which he was well acquainted, he remarked that 'he did not think he had ever seen some points of structure better shown than they were by my $\frac{1}{12}$th.'

"In the following page, 330, the writer asks, 'When an object (other than diatom lines) has been seen with an $\frac{1}{8}$th or $\frac{1}{12}$th, can it not nearly always be shown by the 1th?' To this I answer, emphatically, no, in regard, for example, to the minute structure of nerve-tissue; and in this opinion I am fully borne out by the observations of Dr. Lionel Beale, who has probably done more good work with his $\frac{1}{25}$th than any other observer.—I am, Sir, your obedient servant,

"Chas. Brooke.

"16, Fitzroy Square, *July 14th*, 1864."

RESULTS OF METEOROLOGICAL OBSERVATIONS MADE AT THE KEW OBSERVATORY.

LATITUDE 51° 28′ 6″ N., LONGITUDE 0° 18′ 47″ W.

BY G. M. WHIPPLE.

1864.	Reduced to mean of day.					Temperature of Air.			At 9·30 A.M., 2·30 P.M., and 5 P.M. respectively.		Rain—read at 9·30 A.M.
Day of Month.	Barometer corrected to Temp. 32°*	Temperature of Air.	Calculated. Dew Point.	Relative Humidity.	Tension of Vapour.	Maximum, read at 9·30 A.M. on the following day.	Minimum, read at 9·30 A.M.	Daily Range.	Proportion of Sky clouded.	Direction of Wind.	
	inches.	°	°		inch.	°	°	°			inches.
April 1	29·679	41·4	29·9	·67	·277	50·0	39·5	10·5	6, 5, 3	W, W by S, W.	0·080
„ 2	29·945	42·8	26·8	·57	·291	51·7	35·1	16·6	7, 7, 3	WNW, W by N, WNW.	·012
„ 3	...	...	...	...	..	54·8	38·4	16·4	...	... ...	·006
„ 4	29·913	52·6	48·1	·86	·408	60·4	45·0	15·4	7, 10, 10	NW by W, NW, NW by W	·039
„ 5	30·249	33·0	33·4	1·00	·206	39·7	36·3	3·4	10, 10, 10	ESE, E, E by N.	·267
„ 6	30·220	39·5	37·0	·92	·260	46·2	35·1	11·1	10, 10, 10	SE, E by S, ESE.	·410
„ 7	30·284	43·6	35·2	·75	·299	51·5	40·5	11·0	10, 10, 8	SE, by E, S, SE.	·000
„ 8	30·364	43·8	30·2	·62	·301	51·7	39·0	12·7	10, 9, 7	S, ESE, E.	·000
„ 9	30·237	48·0	40·6	·78	·348	58·0	39·4	18·6	9, 10, 7	NW by W, NW, N by W.	·000
„ 10	...	..	...	...	...	58·2	46·6	11·6	...	... ...	·000
„ 11	30·044	54·8	43·0	·67	·439	63·1	48·2	14·9	5, 8, 3	WSW, NWbyW, NWbyW.	·000
„ 12	30·060	49·1	34·9	·61	·362	57·0	42·1	14·9	5, 3, 0	NE, NNE, NE by N.	·000
„ 13	30·052	45·9	34·8	·68	·324	54·5	34·0	20·5	0, 0, 0	ESE, NE, E.	·000
„ 14	29·873	47·4	34·7	·64	·341	56·7	37·9	18·8	2, 2, 0	E, E, E by S.	·000
„ 15	29·691	55·8	39·7	·57	·454	66·4	38·4	28·0	3, 3, 4	SSE, S by E, SW by S.	·000
„ 16	29·712	42·6	43·6	1·00	·289	48·6	45·5	3·1	10, 10, 10	NNE, NE by N, NNE.	·008
„ 17	...	...	...	...	...	57·1	42·5	14·6	...	... ...	·034
„ 18	30·082	52·1	39·6	·65	·401	61·4	36·7	24·7	1, 6, 1	WSW, SW by S, SW.	·000
„ 19	29·963	57·4	37·8	·51	·479	64·6	35·8	28·8	0, 0, 0	S by E, S, S.	·000
„ 20	29·938	62·7	40 0	·46	·572	70·3	39·3	31·0	1, 2, 1	S by E, S, SSE.	·000
„ 21	30·015	55·3	33·9	·48	·447	66·1	42·3	23·8	3, 0, 0	SE, E by N, E by N.	·000
„ 22	30·161	53·3	33·9	·51	·417	61·3	42·2	19·1	2, 0, 0	ENE, E by S, E by S.	·000
„ 23	30·212	55·9	37·5	·53	·456	64·5	35·2	29·3	3, 0, 4	ENE, ESE, ESE.	·000
„ 24	...	...	...	...	...	53·0	39·6	13·4	...	... ...	·000
„ 25	30·128	49·3	39·4	·71	·364	57·9	39·1	18·8	10, 8, 6	ENE, ESE, E.	·000
„ 26	30·144	47·8	39·7	·75	·346	54·5	41·3	13·2	10, 10, 10	NE, NE, NE by N.	·000
„ 27	30·163	48·3	41·9	·80	·352	58·7	43·9	14·8	10, 10, 4	NE, E by N, ESE.	·003
„ 28	30·103	41·4	38·6	·91	·278	48·7	41·5	7·2	10, 10, 10	N, NNE, N by E.	·007
„ 29	30·122	50·2	39·4	·69	·376	61·7	41·7	20·0	10, 0, 0	N, W, SW.	·000
„ 30	30·138	47·8	38·5	·72	·346	56 2	43·7	12·5	9, 9, 9	NW, W, NE by N.	·000
Monthly Means.	30·057	48·5	37·4	·69	·363	...	...	19·2	...	... ...	0·866

* To obtain the Barometric pressure at the sea-level these numbers must be increased by ·037 inch.

HOURLY MOVEMENT OF THE WIND (IN MILES) AS RECORDED BY ROBINSON'S ANEMOMETER.—April, 1864.

Day.		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	Hourly Means.
Hour.																																
12		13	15	10	12	13	5	4	6	3	4	2	10	4	9	6	5	11	4	3	4	6	10	4	13	7	2	13	13	11	6	7·6
1	A.M.	10	16	7	11	14	5	1	5	4	2	1	7	3	13	4	5	13	5	3	1	8	6	3	13	6	2	15	12	12	3	7·0
2	A.M.	11	13	4	8	15	4	3	5	3	4	1	8	2	14	7	6	11	6	0	2	6	10	1	11	8	2	10	10	12	5	6·7
3	A.M.	12	18	5	9	16	4	4	4	3	5	0	6	3	15	8	6	7	7	1	3	4	14	2	11	8	1	9	10	10	8	7·1
4	A.M.	17	18	5	8	13	3	6	2	5	4	4	8	4	13	9	7	8	8	2	3	3	15	1	12	8	2	13	8	11	5	7·5
5	A.M.	14	15	6	6	13	5	4	4	3	4	5	6	5	14	6	3	10	7	2	2	4	13	2	11	6	1	15	8	10	5	7·0
6	A.M.	13	17	7	7	16	4	5	3	5	2	6	8	4	18	8	5	12	6	1	2	5	17	2	14	8	6	18	9	11	8	8·2
7	A.M.	18	13	9	7	19	7	5	5	5	3	5	11	9	14	10	3	10	7	7	5	5	20	3	13	9	6	16	10	10	11	9·2
8	A.M.	20	12	8	8	19	6	6	10	5	5	4	16	17	16	10	7	12	7	16	11	15	18	6	12	7	8	16	10	11	9	10·9
9	A.M.	21	23	9	10	12	5	7	8	7	8	5	13	17	18	8	8	10	8	17	10	15	19	8	13	8	8	14	9	7	7	11·1
10	A.M.	21	21	12	12	11	5	10	6	5	10	5	12	16	22	10	10	10	9	24	17	16	15	6	13	11	9	12	10	5	7	11·7
11	A.M.	21	22	12	11	11	3	9	11	5	10	7	8	17	18	10	8	10	12	24	20	18	16	7	17	9	10	12	8	7	7	12·0
12		23	24	16	12	12	3	8	9	6	10	8	6	21	23	11	9	12	11	23	22	28	17	11	20	11	11	14	10	5	8	13·5
1	P.M.	21	21	17	8	11	3	8	6	4	9	10	8	26	25	11	10	12	13	18	20	31	18	8	17	11	9	14	9	5	9	13·1
2	P.M.	23	22	15	8	11	3	6	6	3	8	10	8	26	25	12	16	13	15	19	18	35	17	9	14	10	10	14	10	6	9	13·4
3	P.M.	21	20	15	9	14	0	3	3	4	10	5	8	27	29	14	12	13	15	19	15	30	18	8	15	7	9	15	8	9	8	12·8
4	P.M.	21	20	12	7	15	3	5	2	6	13	7	10	26	30	17	15	14	17	20	17	33	14	9	14	9	7	16	11	10	7	13·6
5	P.M.	18	14	14	6	11	3	12	8	5	9	4	7	25	27	7	10	10	14	11	15	32	14	6	14	10	13	14	11	8	4	11·9
6	P.M.	17	11	14	12	9	5	12	8	4	6	2	9	28	20	4	13	8	10	8	9	22	12	3	10	10	14	10	11	11	7	10·6
7	P.M.	18	13	13	10	11	5	12	7	5	1	3	16	23	19	5	14	4	7	5	8	19	7	3	12	10	13	12	9	11	4	10·0
8	P.M.	17	10	14	7	9	4	10	5	6	1	3	18	19	12	5	13	2	7	6	6	16	11	11	13	14	10	12	6	10	3	9·3
9	P.M.	13	11	11	10	8	6	6	2	4	3	8	14	16	13	6	10	3	5	3	10	15	9	16	15	12	8	12	12	7	4	9·1
10	P.M.	12	13	12	13	7	5	8	6	6	2	11	10	17	14	7	12	3	6	4	12	16	11	12	15	6	11	16	12	8	3	9·7
11	P.M.	13	10	12	14	7	4	6	3	4	2	10	5	13	11	6	13	4	4	3	7	14	5	13	9	2	9	13	10	8	1	7·8
12																																
Total Daily Movement.		408	392	259	225	297	100	160	134	110	135	126	232	368	432	201	220	222	210	239	239	396	326	154	321	207	181	325	236	215	148	10.0

RESULTS OF METEOROLOGICAL OBSERVATIONS MADE AT THE KEW OBSERVATORY.

LATITUDE 51° 28′ 6″ N., LONGITUDE 0° 18′ 47″ W.

1864. Day of Month.	Reduced to mean of day. Barometer, corrected to Temp. 32.*	Temperature of Air.	Calculated. Dew Point.	Relative Humidity.	Tension of Vapour.	Temperature of Air. Maximum, read at 9·30 A.M. on the following day.	Minimum, read at 9·30 A.M.	Daily Range.	At 9·30 A.M., 2.30 P.M., and 5 P.M., respectively. Proportion of Sky clouded.	Direction of Wind.	Rain—read at 9·30 A.M.
	inches.	°	°		inch.	°	°	°			inches.
May 1	...	...	...	...	...	62·0	43·4	18·6	...	...	0·000
„ 2	29·810	55·2	49·4	·82	·445	62·5	50·1	12·4	10, 10, 10	W, W, W by N.	·089
„ 3	29·812	51·4	47·5	·88	·391	57·8	51·3	6·5	10, 8, 7	WNW, NNW, NE.	·203
„ 4	29·848	44·0	44·1	1·00	·304	50·6	46·0	4·6	10, 10, 10	E, SE, SE by E.	·090
„ 5	29·950	49·1	44·3	·85	·362	57·3	45·7	11·6	10, 9, 7	S, SE, SSE.	·075
„ 6	29·904	54·3	46·4	·76	·432	65·8	40·8	25·0	7, 6, 5	ENE, SSE, SW by S.	·004
„ 7	29·827	51·8	39·5	·65	·397	60·2	48·5	11·7	2, 4, 3	NW, N by E, NNE.	·529
„ 8	...	...	...	...	...	52·6	41·0	11·6	...	...	·000
„ 9	29·694	41·5	41·5	1·00	·278	53·1	45·2	7·9	10, 10, 10	NE, NE, NE.	·159
„ 10	29·903	50·8	38·2	·65	·383	58·9	45·1	13·8	10, 9, 6	NE, NE by N, NE.	·165
„ 11	29·864	46·4	46·1	·99	·330	53·9	46·5	7·4	10, 10, 10	NE by N, E, E by N.	·004
„ 12	29·774	56·0	48·2	·77	·457	63·1	49·6	13·5	9, 10, 6	NE by E, E, NE.	·002
„ 13	30·047	56·7	45·5	·68	·468	64·6	43·7	20·9	4, 10, 10	N by W, N, N.	·000
„ 14	30·162	61·2	45·9	·59	·544	69·8	41·1	28·7	7, 5, —	NW, ENE, SE.	·000
„ 15	...	...	...	...	...	74·6	51·3	23·3	...	...	·000
„ 16	30·186	62·5	46·4	·58	·568	69·8	52·2	17·6	3, 0, 0	E, E by N, E.	·000
„ 17	30·199	64·5	52·2	·66	·607	74·9	46·4	28·5	10, 0, 0	E, ENE, E.	·000
„ 18	30·216	69·8	52·4	·56	·722	77·4	48·8	28·6	0, 0, 0	NE, N by W, N.	·000
„ 19	30·199	68·9	50·5	·54	·701	77·3	50·3	27·0	0, 0, 0	ESE, E by S, E.	·000
„ 20	30·079	67·4	53·4	·63	·667	76·3	49·9	26·4	0, 0, 2	SW, SSW, SW by S.	·000
„ 21	30·027	51·1	46·9	·87	·387	61·3	49·3	12·0	10, 10, 9	N, N, N by W.	·256
„ 22	...	...	...	...	...	68·4	46·3	12·1	...	...	·002
„ 23	30·053	50·4	40·7	·71	·378	61·2	45·6	15·6	6, 10, 0	NW, NNE, ENE,	·000
„ 24	30·243	49·2	36·2	·64	·363	58·5	36.5	22·0	4, 3, 1	NE, NNE, N by E.	·000
„ 25	29·975	54·3	44·2	·71	·432	62·6	38·5	24·1	0, 7, 10	W by N, NW by W, NNW.	·000
„ 26	30·013	47·8	34·1	·62	·346	54·3	45·5	8·8	6, 9, 10	N by E, NNW, NE by N.	·000
„ 27	30·002	52·1	36·3	·58	·401	61·6	41·5	20·1	2, 4, 4	NNW, SW, NW by W.	·000
„ 28	30·020	51·8	40·1	·67	·397	61·4	45·1	16·3	5, 7, 2	NE, NNE, —	·000
„ 29	...	...	...	...	...	55·3	45·0	10·3	...	...	·000
„ 30	29·922	51·1	38·5	·65	·387	60·3	32·6	27·7	8, 8, 4	SW by S, SW, SSW.	·001
„ 31	29·729	45·2	43·9	·95	·316	58 3	41·1	17·2	10, 10, 10	—, NE, NE by N.	·000
Monthly Means.	29·979	54·0	44·3	·73	·441	...	...	20·5	...	...	1·579

* To obtain the Barometric pressure at the sea-level these numbers must be increased by ·037 inch.

HOURLY MOVEMENT OF THE WIND (IN MILES) AS RECORDED BY ROBINSON'S ANEMOMETER.—May, 1864.

Day.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Hourly Means.
Hour.																																
A.M. 12	2	20	13	7	5	1	7	7	24	8	10	10	5	1	3	1	14	2	1	4	5	4	5	2	5	3	6	5	9	1	5	6·3
1	3	15	12	9	5	1	5	4		10	7	10	2	1	2	2	16	1	0	4	8	4	4	2	5	5	3	4	6	1	5	5·2
2	2	14	13	4	3	1	4	5		8	9	7	1	0	3	2	10	0	1	5	7	4		1	5	9	6	3	6	1	3	4·7
3	0	11	10	5	4	2	3	5		9	10	9	2	1	2	4	2	1	0	5	5	5		0	7	10	5	15	5	1	2	4·8
4	1	11	13	5	3	3	5	5		7	11	10	3	1	2	3	5	1	1	1	8	6		1	5	7	8	8	4	0	1	4·8
5	2	10	12	7	2	3	5	5	206	9	6	9	3	0	1	3	1	1	1	0	8	6		3	6	10	7	6	7	0	1	4·6
6	2	11	16	8	9	4	11	9		13	8	9	2	0	4	4	11	1	0	1	9	5	81	9	8	13	10	7	9	1	3	6·8
7	4	13	18	11	6	4	12	18		14	9	12	6	2	1	4	12	2	2	1	9	8		11	8	18	8	4	10	6	5	8·2
8	5	13	15	10	9	4	12	25		15	8	13	8	0	1	6	9	1	7	3	14	10		9	11	16	8	11	11	8	2	9·1
9	7	12	18	9	7	3	11	27		17	9	15	11	3	2	8	10	2	9	7	13	8		7	11	14	7	7	11	8	3	9·5
10	5	15	19	6	7	3	15		15	21	6	16	10	2	2	12	9	6	10	9	16	11	18	8	13	15	7	6	11	5	5	10·1
11	8	16	22	6	5	9	15		15	21	8	16	10	3	3	14	7	12	10	13	13	12	15	9	15	17	6	5	7	10	11	11·1
12	9	14	19	8	8	9	13		18	20	9	17	11	4	5	18	8	7	12	14	11	13	19	9	14	16	8	6	14	14	14	12·2
P.M. 1	11	18	16	8	8	10	10		19	19	10	12	10	3	3	21	6	7	13	14	11	16	20	8	12	15	7	5	10	14	13	11·6
2	10	20	15	10	10	12	9		16	17	13	10	11	3	2	25	8	7	12	17	14	15	16	9	12	14	5	4	8	15	12	11·7
3	10	17	11	12	8	12	11	328	14	21	16	20	11	3	5	17	12	7	10	17	10	14	17	7	11	15	7	4	8	17	13	11·9
4	10	16	7	9	9	10	9		13	16	16	17	11	2	3	16	14	7	12	19	8	13	14	7	7	11	7	3	13	17	14	11·0
5	12	16	6	7	9	10	9		10	17	15	13	8	2	3	19	11	6	16	15	9	12	15	7	8	14	9	4	12	12	15	10·7
6	8	16	7	8	9	8	6		9	16	12	9	5	1	1	15	12	4	13	14	1	5	13	7	4	10	6	10	9	8	13	8·6
7	11	13	5	9	5	5	6		8	13	16	6	3	3	1	13	8	4	13	15	2	7	8	2	7	9	5	9	8	15	12	8·0
8	12	10	5	7	5	7	7		8	8	14	7	2	0	2	16	7	1	11	11	2	7	8	1	7	7	6	7	6	2	11	6·8
9	12	7	9	4	5	10	5	23	9	7	10	9	1	1	1	15	2	1	8	9	4	6	9	4	5	7	8	10	5	1	8	7·0
10	14	2	6	3	5	9	6	21	11	10	8	10	4	0	1	17	4	1	6	9	5	3	7	6	7	8	6	12	5	3	8	7·0
11	16	5	10	5	1	12	5	25	9	9	13	6	4	2	1	13	2	2	7	12	3	3	9	5	2	6	3	10	3	4	7	7·0
12																																
Total Daily Movement.	176	315	297	177	147	152	201	507	404	325	253	272	144	38	54	268	200	84	175	219	195	197	278	134	195	269	158	165	197	164	186	8·8

RESULTS OF METEOROLOGICAL OBSERVATIONS MADE AT THE KEW OBSERVATORY.

LATITUDE 51° 28′ 6″ N., LONGITUDE 0° 18′ 47″ W.

1864.	Reduced to mean of day.					Temperature of Air.			At 9·30 A.M., 2.30 P.M., and 5 P.M., respectively.		
			Calculated.								
Day of Month.	Barometer, corrected to Temp. 32°.*	Temperature of Air.	Dew Point.	Relative Humidity.	Tension of Vapour.	Maximum, read at 9·30 A.M. on the following day.	Minimum, read at 9·30 A.M.	Daily Range.	Proportion of Sky clouded.	Direction of Wind.	Rain—read at 9.30 A.M.
	inches.	°	°		inch.	°	°	°			inches.
June 1	29·757	48·5	43·1	·83	·354	57·6	43·4	14·2	7, 10, 9	NE, ESE, SSE.	0·305
„ 2	29·782	50·9	38·9	·66	·384	59·2	43·1	16·1	10, 9, 8	E, E by S, E by S.	·000
„ 3	29·836	45·8	45·9	1·00	·323	54·2	49·7	5·5	10, 10, 10	NE, NE by E, NE.	·253
„ 4	29·919	55·5	39·9	·58	·450	64·8	43·2	21·6	0, 1, 2	NNE, NE, —	·055
„ 5	...	...	...	...	...	66·8	44·9	21·9	...	... ...	·000
„ 6	29·987	61·3	46·8	·61	·546	70·5	52·3	18·2	6, 3, 1	SW by W, SW, WSW.	·000
„ 7	29·938	63·2	39·8	·45	·581	74·8	46·1	28·7	0, 3, 2	SW by W, W, NW.	·000
„ 8	29·878	61·5	48·7	·65	·550	72·2	53·3	18·9	7, 5, 5	NW by N, NW, W by N.	·000
„ 9	29·765	56·1	50·9	·84	·459	68·8	47·6	21·2	7, 7, 10	SE, SW by S, SW.	·000
„ 10	29·902	58·9	44·8	·62	·504	69·4	47·1	22·3	2, 4, 2	W by S, W, SW.	·217
„ 11	29·831	56·2	44·1	·66	·460	66·9	...	...	3, 5, 6	W by S, SW, SSW.	·024
„ 12	...	...	...	...	...	68·8	47·1	21·7	...	... ...	·000
„ 13	29·643	53·8	47·4	·80	·424	65·0	49·7	15·3	10, 7, 2	—, SE by E, SW.	·142
„ 14	29·542	55·8	45·5	·70	·454	66·5	45·8	20·7	10, 8, 9	SSE, SSW, SSW.	·525
„ 15	29·635	50·8	44·9	·81	·383	62·7	50·2	12·5	9, 7, 8	SW, SW, WNW.	·144
„ 16	29·888	58·6	48·0	·70	·499	67·8	45·2	22·6	5, 5, 7	W by N, SW by W, W by N.	·032
„ 17	30·107	59·4	53·1	·81	·512	71·4	50·3	21·1	10, 9, 9	SW, WSW, SW.	·000
„ 18	30·065	59·7	45·4	·61	·518	68·8	56·6	12·2	3, 4, 3	NW by W, W by S, W.	·000
„ 19	...	...	...	...	...	66·0	50·0	16·0	...	... ...	·000
„ 20	30·202	60·2	48·3	·67	·526	70·0	49·2	20·8	5, 2, 1	SW by S, SW, SW by S.	·000
„ 21	30·110	58·8	41·4	·55	·502	67·3	53·9	13·4	4, 4, 2	W by S, W, W by S.	·002
„ 22	30·098	57·0	49·7	·78	·473	66 0	49·9	16·1	10, 9, 10	W by S, SW by S, SW.	·000
„ 23	29·946	55·3	45·4	·71	·447	65·6	52·1	13·5	10, 4, 2	SW, W by S, S.	·015
„ 24	30·178	54·7	41·4	·63	·438	65·4	47·7	17·7	7, 10, 8	W by N, SW by W, W by S.	·176
„ 25	30·033	58·6	53·1	·83	·499	68·1	54·2	13·9	10, 10, 8	W by S, SW, W by N.	·005
„ 26	...	...	...	...	...	67·5	55·4	12·1	...	... ...	·057
„ 27	30·141	53·5	40·6	·64	·420	61·3	45·8	15·5	4, 10, 9	NW, N, N.	·005
„ 28	30·113	54·7	47·7	·79	·438	64·8	47·7	17·1	10, 10, 10	W by N, W, W.	·000
„ 29	29·987	57·0	47·2	·71	·473	68·6	53·9	14·7	5, 10, 10	W, SW by W, W by S.	·065
„ 30	29·910	56·8	44·2	·65	·470	66·3	54·4	11·9	7, 3, 6	NNW, WSW, NW by W.	·042
Monthly Means.	29·930	56·3	45·6	·70	·465	...	...	17·2	...	... ...	2·064

* To obtain the Barometric pressure at the sea-level these numbers must be increased by ·037 inch.

HOURLY MOVEMENT OF THE WIND (IN MILES) AS RECORDED BY ROBINSON'S ANEMOMETER.—JUNE, 1864.

Day.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	Hourly Means.
Hour.																															
A. M. 12	7	4	13	6	5	12	4	3	5	6	8	9	0	6	10	6	8	16	8	4	15	7	8	12	15	7	8		8	8	7·9
1	7	4	11	6	1	10	5	3	5	3	9	9	0	4	11	7	7	17	7	5	12	6	5	13	13	4	7		9	9	7·2
2	3	3	11	3	4	7	2	2	7	7	12	6	1	3	13	8	5	16	7	4	12	9	3	12	12	8	5		6	8	6·9
3	4	5	10	3	1	9	0	3	6	3	12	4	0	2	12	6	8	16	6	2	11	10	3	12	11	6	4		5	9	6·3
4	6	5	8	4	4	9	3	4	9	5	10	2	0	5	13	7	5	17	8	7	12	6	11	10	14	6	4		5	9	7·2
5	5	8	7	5	5	10	4	3	8	7	9	6	0	4	10	7	8	14	7	7	15	7	14	10	10	6	7		5	8	7·5
6	7	6	8	6	5	12	2	5	10	9	6	10	1	11	14	11	8	14	12	10	14	11	15	10	14	7	11		8	10	9·2
7	7	4	7	9	4	14	4	8	6	10	12	11	2	11	14	10	9	16	13	15	14	14	18	15	14	9	14		9	14	10·6
8	8	3	10	9	11	12	5	4	4	8	11	11	1	12	12	15	10	19	10	15	13	15	15	14	15	10	14		8	12	10·6
9	6	5	10	8	11	10	4	11	5	11	11	12	2	14	11	14	13	15	12	17	15	17	17	16	10	9	14		12	14	11·2
10	5	7	13	7	13	12	7	7	7	12	14	14	1	15	16	16	12	18	11	15	15	16	21	15	10	4		9	8	15	11·6
11	2	9	14	8	17	10	6	5	13	10	15	13	3	10	14	13	13	17	14	19	15	17	19	15	11	9		9	10	16	11·9
P. M. 12	5	11	15	7	17	10	7	8	13	11	16	15	3	17	14	13	18	17	15	19	19	17	23	18	7	8		11	12	13	13·1
1	4	15	11	5	17	10	7	7	14	9	21	14	6	20	9	14	16	16	11	17	21	18	13	16	10	13		12	13	15	12·9
2	4	19	14	6	19	10	6	10	15	10	21	17	3	19	14	15	16	17	11	17	20	14	18	12	12	12		11	12	15	13·4
3	5	23	13	3	19	10	5	9	12	10	18	17	6	16	13	15	20	13	14	18	17	20	20	15	13	14		6	9	16	13·4
4	7	14	15	1	20	10	4	9	4	9	23	15	15	16	12	13	20	18	12	20	20	22	21	19	14	15		9	9	14	13·8
5	5	14	12	1	20	8	4	9	6	9	21	14	18	17	6	11	20	18	10	18	18	21	21	17	13	16		6	8	13	12·9
6	6	10	10	2	19	10	5	8	5	15	15	12	17	14	12	8	18	13	8	15	15	16	20	16	10	15		8	7	11	11·7
7	8	9	15	7	18	3	6	4	5	12	11	9	13	14	10	11	14	13	5	13	11	11	13	11	10	12		7	10	7	10·1
8	7	7	10	7	18	3	4	6	4	10	11	5	11	15	9	7	13	13	4	9	9	11	10	8	6	12		7	11	7	8·8
9	5	14	10	6	15	2	4	5	5	5	11	2	10	15	7	4	14	10	5	10	7	8	9	8	12	10		7	9	5	8·1
10	5	13	10	7	16	3	1	8	7	6	12	3	6	16	9	10	19	7	6	15	7	9	13	15	9	10	175	10	12	7	9·4
11	3	12	8	5	12	2	4	7	4	6	7	2	5	10	8	7	15	7	5	13	4	6	13	10	7	10		7	9	8	7·4
12																															
Total Daily Movement.	131	224	265	131	291	208	103	148	179	203	316	232	124	286	273	248	309	357	221	304	331	308	343	319	272	232	382		214	263	10·0

DOUBLE STARS.—COLOURS OF STARS.

BY THE REV. T. W. WEBB, A.M., F.R.A.S.

It is now a considerable time since we have pointed out any of these interesting objects; but we must not lose the present opportunity of adding one more to our list before it gets away into the twilight; not visible indeed to the naked eye, but easily found at the present season. The pretty little constellation, *Corona Borealis*, always readily distinguished by its form, passes the meridian, at a considerable elevation, about six o'clock at the middle of this month, and consequently will be verging toward the W. when our observations begin. Directions for finding its *lucida* α, or *Gemma* as it is sometimes called, are given in connection with No. 35 of our "Double Star List," at p. 134 of the Intellectual Observer, for September, 1862. If we have an equatorial stand, we have only to sweep on the parallel of α a little towards the W. for the star, which is but 10′ further N.; or with an ordinary altitude and azimuth movement to move the telescope a little to the right of α, and somewhat below it, in the direction in which α is declining; then at a distance of $2\frac{1}{2}°$, which is the breadth of a field of my 14 inch finder, we shall come upon a small star. We shall pass by several gleaming points before we reach it, but it is the first star in that direction large enough to be at all conspicuous with my $1\frac{1}{10}$th inch aperture. It was long before I could find it, from a mistake as to its nomenclature. It is *not*, as I supposed, the 1 *Coronæ* of Flamsteed, which is duly entered in the larger star map of the S. D. U. K., and lies further N.; but, as Mr. Knott* pointed out to me, *Coronæ* 1 of Bode, or No. 1932 of Struve, and will be, in our "Double Star List"—

124. The data, in Struve's Catalogue, as the mean of four years, are, 5·6 and 6·1 (of his scale), 1″·622, 273°·85. 1830·28. Both very white; with a suspicion, from discordant comparisons of magnitude, of variable light. Mädler, however, having found 1″·536 and 278°·47, 1839·52, and Secchi 1″·149 and 285°·37, 1856·401, the latter has suspected motion, which has been confirmed by Dembowski, who gives 1″·180 and 290°·27, 1863·28. So that we may look upon this very elegant little pair as a binary system—which, indeed, its mere appearance would indicate. In crowded parts of the sky, and with much inequality of magnitude, juxtaposition may be naturally referred to mere perspective, and the probability would be against the binary character of a very unequal

* This gentleman's name was erroneously printed "Knox" in our last number.

double star in a galaxy field. But in a comparatively barren region, and with magnitudes approaching equality, the very aspect of a close pair, such as the present, is sufficient to convey a strong impression of actual nearness, and consequent physical connection, which must be the inevitable result if gravity is, as we have every reason to suppose, universal.

This beautiful object was usually employed by Smyth as a test for definition and focus, before proceeding to attack η *Coronæ*, in those days so severe a trial both of atmospheric steadiness and optical power. Of late, however, that remarkable binary has become comparatively easy; the components have been opening for several years, and may now be well dealt with by any good telescope of moderate size. A power of 170 on my 5½ inch aperture will just divide them in favourable weather; they are widely separated with 600.

The Baron Dembowski, whose observations have just been referred to, and whose labours in star-measurement are well known to astronomers, has recently been increasing his optical power. His former series of measures, commencing at Naples ten years ago, and continued till 1858, was made with a "Dialyte,"—a peculiar construction of refracting telescope, very little known in England, but of which we hope before long to give an account. Since June, 1862, he has been observing with an achromatic of seven French inches aperture (two inches more than his previous instrument), made by Merz, the successor of the celebrated Frauenhofer, and placed in an observatory at Gallarate, a town of North Italy, twenty-five miles, by rail, N.W. from Milan, near the end of the Lago Maggiore, and commanding a view of the Alps in the distant north horizon. He speaks most highly of his telescope, as enabling him to measure all but the most difficult of the double stars in the Dorpat Catalogue. The mode of micrometric illumination is described as very efficient. Two little lamps so suspended upon an axis coincident with the flame as to be vertical in all positions of the instrument, give light, the one to the field, so as to render the dark micrometer-threads apparent, the other to the threads, making them visible in a dark field; the former, however, he finds so superior that he now employs it exclusively. Two concentric revolving discs intervene between the light and the micrometer; one of which regulates the quantity of light by its admission through openings of different sizes; the other, divided into quadrants, changes the ground of the field by interposing, at the observer's pleasure, yellow, red, blue, or plain glass. The fact that the colour of the field exercises considerable influence upon the visibility of some objects was pointed out by Sir J. Herschel, and, in accordance with his suggestion, Smyth employed a red screen

for his micrometer-lamp, with so much advantage that he could never tolerate green again. And in the same manner Dembowski finds that a vermilion illumination has "un effet surprenant,"—stars even of the three smallest magnitudes of Struve's scale, barely visible in a dark field, and entirely effaced by the approach of the illuminated threads, becoming not only visible, but in general even measurable, upon a red background. That the effect of contrast, in bringing out the blue light so frequent (as we shall hereafter remark) among minute *comites*, is not concerned in this curious result, is evident from the Baron's further remark, that blue is next in good effect to red, yellow least favourable of all.

The Baron has noticed a source of discordance in his measures of position, which it may be useful to mention. He has found the values differ very sensibly according to the direction in which the position-circle is made to revolve, and hence takes a mean of the results obtained in each direction. The deception is only of occasional recurrence, and may be an individual peculiarity; the supposition, however, that other eyes may be similarly affected, would account, he observes, for some discrepancies in the measurements of position by different observers at the same epoch.

The perfection of his optical means may be estimated from his having repeatedly *measured* the distance of the close pair, or technically speaking A and B, of ζ *Cancri*, during 1863, giving at a mean about $\frac{3}{4}''$. Those among our readers who are acquainted with this object will readily comprehend the difficulty of the feat. In general, however, his values under $1''$ are only estimations.

The Baron's observations, which will no doubt be published, as heretofore, from time to time, will be looked for with the greater interest, as the results of the measurements of a very large number of double stars taken from Struve's class of "lucidæ," during the past year, with the Oxford heliometer, have not borne out that astronomer's impression as to their binary character. The modes of measurement, however, are essentially different — the heliometer values being obtained from the doubled image produced by a divided object-glass, the halves of which are relatively moveable, those of Dembowski and Struve from the parallel-thread micrometer.

COLOURS OF STARS.

We are induced to offer a few additional remarks upon this curious subject, that it may be presented in a less incomplete form before our readers.

As the susceptibility of different eyes varies both with regard to the intensity and colour of light, it must be expected

that much difference will exist as to the inferior limit of perceptible colour in stars. Struve I. terminated his observations of colour in the Dorpat Catalogue with the 9th out of the 12 magnitudes of his scale, corresponding with the respective numbers 10 and 16 of Smyth. The latter observer carried his estimates much lower, occasionally even down to his 16th magnitude, or about 11·2 of Struve's scale, and was struck by the "strong blue ray" emitted by some of the minutest points among the double stars. We find as specimens of this a 15 mag. (*ε Virginis*) of an intense blue—a very striking colour, he remarks, in so small an object:—a 14 mag. (113 P. XX. *Vulpeculæ*, R. A. 20h. 17m., D. N. 23° 39′) "indigo, an intense colour to the averted eye;" an instance the more remarkable, as no contrast could be induced by the bluish white of the principal, an 8 mag. star:—a 15 mag. (*ι Ceti*) deep blue:—a 14 mag. (52 Piscium, R. A. 0h. 25m., D. N. 19° 33′) of the same tint. And though this would seem to be the prevailing hue of minute components, yet others are occasionally to be met with; such as the orange of the 13 mag. companions of 7. *Camelopardi* (R. A. 4h. 46m., D. N. 53° 32′) and 2 *Lacertæ* (R. A. 22h. 15m., D. N. 45° 51′), the purple of the similar-sized attendants of *κ Pegasi* and *ι Ursæ Majoris*, the emerald of the equivalent "comes" of 42 *Piscium* (R. A. 0h. 15m., D. N. 12° 44′), and even the pale red of the 16th or smallest magnitude in the Bedford telescope (5·9 inches aperture), attached to 212 P. XIV. *Libræ* (R. A. 14h. 49m., D. S. 20° 47′). These, among other instances, will show how far an originally delicate and finely-educated eye will push its perceptions of colour. I have usually found my own sight at fault with regard to very minute stars; but not without exceptions; for example, 144 P. XIX. *Aquilæ* (R. A. 19h. 24m., D.N. 2° 37′), the attendant of which, 11 mag. according to Smyth, but as I thought large for that rating, being *known* to be green, could be readily seen of that hue with $3\frac{7}{10}$th inches of aperture. Some further remarks have still to be postponed to a future opportunity.

PROCEEDINGS OF LEARNED SOCIETIES.

BY W. B. TEGETMEIER.

GEOLOGICAL SOCIETY.—*June* 22.

On some Bone Deposits of the Reindeer-period in the South of France. By John Evans, Esq.—The deposits to which the author particularly called attention are those which have been, and are still being explored under the direction of MM. Lartet and Christy.

Mr. Evans first gave a detailed description of the physical features of the valley of the Vézère, and of the contents of the caverns of Badegoule, Le Moustier, La Madelaine, Laugerie-Haute, Laugerie-Basse, the Gorge d'Enfer, and Les Eyzies, giving a list of the animal remains discovered, which are, for the most part, of the same species from all the caverns.

The author then discussed the antiquity of the deposits according to four methods of inquiry, namely, from geological considerations with regard to the character and position of the caves; from the palæontological evidence of the remains found in them; from the archæological character of the objects of human workmanship; and from a comparison with similar deposits in neighbouring districts in France; and he came to the conclusion that they belonged to a period subsequent to that of the *Elephas primigenius* and *Rhinoceros tichorhinus*, but characterised by the presence of the Reindeer and some other animals now extinct in that part of Europe.

On the former Existence of Glaciers in the High Grounds of the South of Scotland. By J. Young.—The heights bordering the counties of Peebles and Dumfries contain well-preserved remains of a group of glaciers belonging to a later period than the Boulder-clay, some of which have been already alluded to by Mr. Geikie and Mr. Chambers. Dr. Young described the physical geography of the region, grouping the several hills into three ranges—the Broad Law Range, the White Coomb Range, and Hartfell,—from which certain glaciers formerly descended into the valleys. These glaciers may be divided into two classes, the "Social" and the "Solitary." The author described the form and extension of the masses of detritus which he considers to be glacial débris, contrasting their characters with those of the patches of Boulder-clay occurring in the neighbourhood. In addition to the moraine matter, smoothed surfaces and *roches moutonnées* are occasionally seen. Many of the indications of glaciers are much obscured by the prevalence of peat in the district.

GEOGRAPHICAL SOCIETY.—*June* 27.

Recent Explorations in Central Asia.—M. Vámbéry, a Hungarian traveller, who has recently penetrated, in the disguise of a Dervish, into many parts of Central Asia that have not been visited

by any European since the time of Marco Polo, gave a most interesting account of his adventures. Being anxious to trace if any connection existed between the Magyar language and that spoken in Central Asia, he joined at Teheran a company of poor pilgrims who were returning to Tartary from Mecca, giving out that he was visiting Central Asia with a religious object. He crossed the Caspian Sea in a Turcoman corsair, and landed at Geumushtepe, where he visited the remains of a fortified embankment with turrets, built by Alexander the Great; this extends about one hundred miles inland. He then crossed the Hyrcanian desert, and, after a dreary journey of twenty-two days, reached Khiva. The country around Khiva is governed in a most tyrannical manner, the ruler being a bigoted and bloodthirsty Mahommedan. The district in some parts is remarkable for its luxuriant fertility.

From Khiva, Mr. Vámbéry proceeded to Bokhara, distant ten or twelve days' journey, on camels. On this journey the company were obliged to make a detour into the desert of Djan-bantiran (the Life-destroyer) to avoid a noted band of Turcoman robbers. Here they suffered severely from thirst, two of the party dying. Bokhara is described as a large city, with palaces and mosques built of stone. The entire population of the Khanet is estimated at about two million people. From Bokhara, M. Vámbéry proceeded to Samarcand, passing through a populous and cultivated country. Samarcand, the ancient capital of Timour the Tartar, is in a state of decay; but M. Vámbéry considered that its former extent had been greatly exaggerated. The remains of some of the buildings erected during the time of Timour still exist, such as those of the palace, with its throne, consisting of a huge block of greenstone, evidently conveyed from some distant country, and a magnificent portico upwards of one hundred feet high, inlaid with mosaic work; this is regarded as the remains of a medres, or college, built by the wife of Timour. Continuing his journey, M. Vámbéry arrived at Herat in October.

M. Vámbéry is the first European who has visited Samarcand for 450 years; his journey was performed in great peril and at the constant risk of his life. The country through which he passed is of great political importance to England, as during the last twenty-five years the Russian and English encroachments have extended the respective frontiers over a breadth of upwards of one thousand miles, and now there is only a distance of from five to six hundred miles between them.

ENTOMOLOGICAL SOCIETY.—*July* 4.

On the Formation of the Cells of Bees.—Mr. Tegetmeier exhibited several specimens of combs of the hive bee, showing cells of various forms, some being right-angled, others pentagonal, and a large number circular. Mr. Tegetmeier maintained that the cells were always hemispherical at their commencement, the bees excavating hemispherical cups out of the deposited wax. That these excavations were made near each other, and enlarged until they

came into contact, when the cells of necessity became regular hexagons. It was maintained that the theory which attributed the hexagonal form of the cells to pressure, had no foundation in fact, and that the geometrical instinct was entirely suppositious; the actual form of the cell being a consequence of the law that six circles of equal radii will just surround a seventh; and that, had it been the case that seven circles would surround another of equal radius, the cells of bees, when in contact, would have been heptagonal, instead of hexagonal.

ETHNOLOGICAL SOCIETY.—*July* 5.

On the Modes of Measuring the Skull.—At a special meeting of the society, Professor Huxley described some skulls recently brought from Japan, and made some important remarks on the general principles of skull measurement. The skulls of the different races of men vary in several respects, as in the proportion of their extreme length to their greatest breadth, in the width of the face, in obliquity of the margin of the jaws, and in the projection of the jaws beyond the forehead.

The last two variations are generally expressed by the employment of Camper's Facial Angle, but it was shewn that this angle did not merely express the relative development of the anterior parts of the skull, as is frequently imagined, but that its size depended on several circumstances, as the development of the jaw, the position of the auditory foramen and the extension of the brain cavity forwards, so that two skulls may differ very greatly, and yet possess the same facial angle.

Professor Huxley showed that the best method of correctly comparing skulls, was to make a vertical and longitudinal section of each so as to detremine the "basi-cranial axis," which is a line drawn forwards along the inside of the skull, from the front of the occipital foramen to the anterior end of the sphenoid bone. When skulls are bisected and examined in this manner, the vertical measurement or depth of the face can be at once determined, and the relative development of that part of the cerebral chamber lying before the front end of the cranial axis can be compared with that lying behind it. In some of the prominent jawed or prognathous skulls of the lowest human races, the distance between the front end of the axis and the back of the cerebral cavity is only four times as great as the distance to the front of the cavity, whilst in other skulls belonging to the highest developed races, the posterior measurement is as much as seven times as great as the anterior.

In the early fœtal skull, the posterior measurement is three times as great as the anterior. As the European child developes, the posterior part of the cranial cavity grows rapidly, the anterior remaining almost stationary, and the face grows downwards rather than forwards. In the lowest races the infantile measurements of the crania are retained, and the jaws develope forwards as well as downwards.

Professor Huxley regarded the greater development in the higher races, of those parts of the brain situated behind the basi-

cranial axis, as entirely subversive of the location of organs as adopted by the phrenologists.

BRISTOL NATURALISTS' SOCIETY.

From the second annual report of this Society, we learn that it has 214 ordinary and 15 honorary members. Its transactions for the past year exhibit great activity, and the council has recently determined upon a course of action worthy of all praise, and which, we trust, will be imitated in other localities. We allude to the adoption of a resolution proposed by the Hon. Secretary, Mr. William Lant Carpenter, that the Society should undertake a complete natural history of the neighbourhood, comprising its geology, palæontology, mineralogy, botany, and zoology. Looking to the scientific attainments of many members of the Society, and the zealous spirit by which all seem animated, we shall watch with confidence and interest the progress of this great work; and we may remark that few cities equal Bristol in the variety and interest of the circumjacent formations.

NOTES AND MEMORANDA.

METRICAL GLOBE.—M. E. Gosselin has presented to the French Academy a specimen of a new terrestrial globe embodying recent geographical discoveries, and made to a scale of $\frac{1}{50.000.000}$. Its circumference being 80 centimetres, two millimetres measured on it, represent 100 kilometres. In the colouring, blue represents water, and bistre mountains.

VARIABLE STAR, *Lalande*, 40,196.—M. H. Goldschmidt publishes in the *Astronomische Nachrichten* observations on the above star, which he names T. Aquarii, in conformity with Argelander nomenclature. He makes its period 197 days. Last year he found its light decreasing during 78 days, and it was invisible for 61 days. In 1861 it grew larger during 56 days. It is a 7 mag. star, R.A. 20h. 39m. 23s.; Dec. 5° 52′ 43″.

SUTURE OF A NERVE.—M. Langier details in *Comptes Rendus* the particulars of his success in obtaining by means of a suture a reunion of the median nerve which had been severed by an accident. His patient in consequence of the division of the nerve lost all sensation in his thumb and two adjacent fingers, and was unable to place the thumb in opposition. A return of sensibility began on the evening of the day of operation, and was more marked on the day following, after which progress was rapid. M. Langier considers that this interesting experiment proves—1. That after the suture of a severed nerve, sensibility and motion are noticeably restored to the affected parts in a very few hours. 2. That the re-establishment of functions is progressive. 3. That it is successive, as tactile sensations and motions are obtained before sensations of pain and temperature. 4. That the suture of a nerve, as he performed it, does not occasion special pains or serious disturbances. 5. That the operation may be successfully performed on nerves of considerable size.

DRINKING AND CORPULENCE.—M. Dancel has laid before the French Academy some experiments and observations on corpulence, from which he deduces the conclusion that it is greatly promoted in man and animals by drinking much fluid, and may be reduced by diminishing the liquid supply.

PARALYSIS, FROM VERTEBRAL DISPLACEMENT, CURED.—M. Maisonneuve of the Maison Dieu recently had for a patient a girl of sixteen, suffering from general paralysis in consequence of a displacement of the second cervical vertebra by which the chin was pressed down on the collar-bones and the spinal marrow

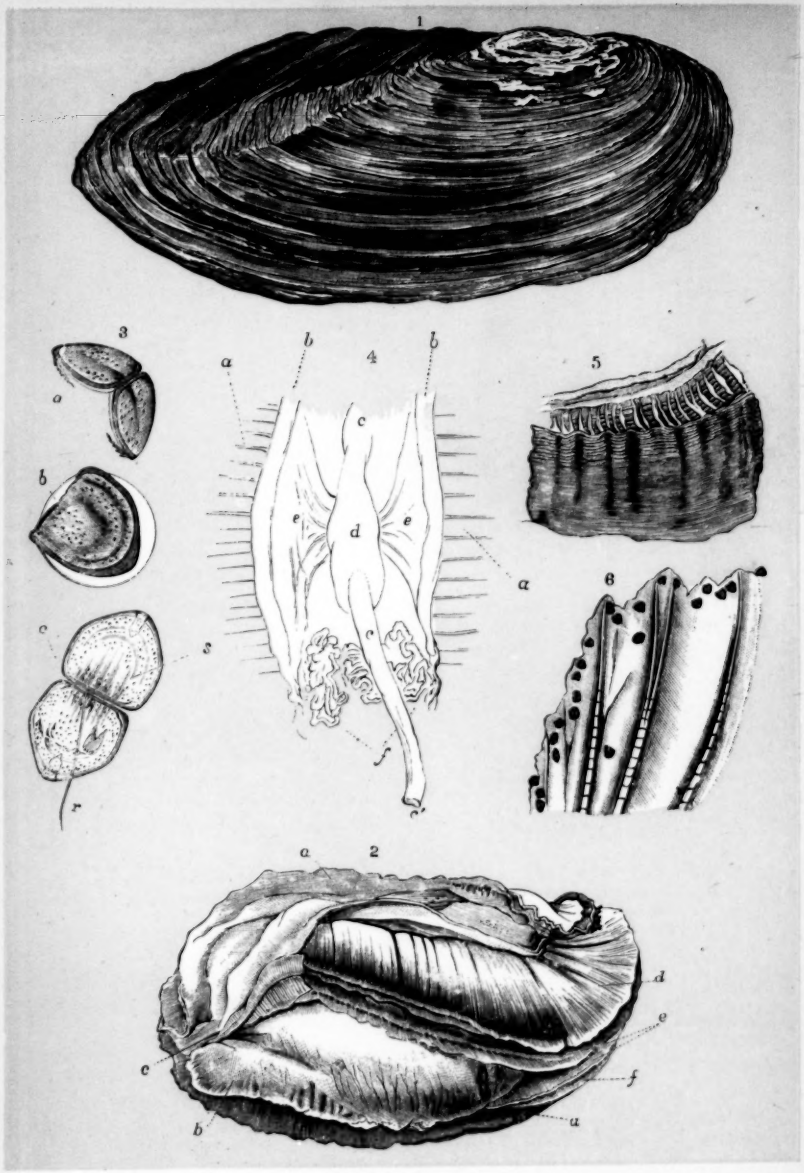
squeezed. Three months before the paralysis the girl had experienced pain and difficulty of moving her neck. On this account she entered the hospital, and in the following night her head fell forwards and paralysis ensued. Her face retained its colour and a lively expression; but her body was like a corpse, and death would have followed had not the diaphragm preserved its action and maintained respiration. M. Maisonneuve succeeded in replacing the vertebra in its proper situation, and recovery was immediate. To avoid a repetition of the accident an artificial support was arranged for the head.

Growth of Spirogyra.—The elegant plants of this genus are universal favourites with microscopists, many of whom will no doubt like to make the experiment suggested by Karsten in his papers on the vegetable cell, which are translated in *Annals Nat. Hist.* "If a spirogyra be allowed to grow for a considerable time in pure water, free from organic compounds and from dead and dying organisms, and its joint cells be observed from time to time, they are found to undergo an unusual increase in length, and sometimes a certain augmentation in width. At the same time the circular (spiral) bands of chlorophyll diverge and become more oblique; their extremities, which were situated in the vicinity of the septum, or even bent towards its central point, are gradually removed from the septum, ... and at length the chlorophyll bands lose their spiral direction and became almost straight. . . . . But if a small quantity of the mucilaginous juices of the same species or of some other conferva be added to the water wherein the starved spirogyra is placed, a new vital energy manifests itself;" and the result is that transverse septa are found in the joints, and the chlorophyll bands grow in their true direction.

Magnus on the Constitution of the Sun.—*Poggendorff's Annals and Archives des Sciences* contain the paper from which M. Magnus remarks that if a little soda is introduced into a non-luminous gas flame, it becomes luminous, and at the same time its heat-radiating power is augmented. The flame must have lost heat by vapourizing the soda, but still it emitted nearly one-third more heat. If a plate of platina was introduced instead of the soda, the radiation was still greater. When a little soda was put on the platina the effect increased, and a still further augmentation of emitted heat occurred if some soda was also introduced into the flame below the platina. In the latter case, three times as much heat was radiated as when the flame was employed without any addition. From these experiments M. Magnus concludes that solid bodies radiate much more heat than gaseous bodies, and consequently he thinks that solar heat cannot reside in a photosphere composed of gas or vapours.

Lieberkuhn on Sponges.—This observer states that when sponges are about to perish they emit prolongations which detach themselves and glide over vacant portions of the silicious skeleton, at the bottom of the vessel in which they are kept. The detached portions will be found at the end of a few weeks to have developed silicious needles and vibratile cilia. Dying sponges also separate into fragments that perish, and cannot at first be distinguished from the divided portions destined to live. The latter put forth filaments like actinophrys, and some of them become encysted. Out of the cysts came four or five monads with one whip, which can swim or creep like amœbæ. These objects are not integral portions of the sponge, and similar bodies appear in the eggs of other animals when they are perishing.—*Archiv. f. Anat.*; *Archiv. des Sciences.*

Pouchet on the Fission of Animalcules.—M. Pouchet considers fission much more rare than is generally affirmed. He denies that fissiparity exists among the vorticellids. During twenty years he has never seen it in any vorticellid. In some rare cases he has seen two of these creatures soldered together. A more common monstrosity he finds to consists in two individuals at the end of the same stalk, and this he considers has been taken for the closing stage of fissiparity. Small, free vorticellids, he states, will also give rise to such an appearance, by attaching themselves parasitically to larger ones.



THE SWAN MUSSEL, (Anodonta cygnea.)

Fig. 1. Shell of Anodonta cygnea.

Fig. 2. Animal of ditto. a, Mantle. a', ditto, folded back. b, Foot. c, Labral pairs. Inner surface. d, Outer gill distended with embryos. e, Inner gills. f Outer gill

Fig. 3. Embryos. a, Shewing open valves and serrated hooks. b, Closed valves surrounded by chorion. c, Open valves, shewing adductor muscles (s) and origin of byssus filament (r).

Fig. 4. Shewing heart, etc. a Gills. b. Branchial arteries. cc. Rectum passing through ventricle of heart (d). ee, Auricles. c', Anus. f, Portion of organ of Bojanus.

Fig. 5. Portion of outer gill, shewing septa or divisions for reception of eggs etc.

Fig. 6. Portion of fin of fish, with parasitic embryos.

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THE SWAN-MUSSEL AND ITS ANATOMY.

BY THE REV. W. HOUGHTON, M.A., F.L.S.

(With a Tinted Plate.)

WHAT collector of shells is unacquainted with the form of the fresh-water mussel, as it lies half buried in the mud, with its back or umbonal region, easily recognized by its white pearly appearance, above the surface; or as the same animal lies flat on the bottom of the river or pond, with its large, broad, and semi-transparent foot protruded between the valves of the shell two inches or more? The swan-mussel (*Anodonta*), of which the most recent English authority* recognizes two British species, the *Anodonta cygnea* and the *Anodonta anatina*, is one of the largest of our bivalve molluscs, and its study a matter of curious and more than ordinary interest, especially in that portion of its history which relates to the development of the young fry.

The *Anodonta*,† so named from the absence or very rudimentary condition of the teeth of the *hinge*, belongs to the family *Unionidæ*, a group of the *Conchifera*, or Bivalves, of the order *Lamellibranchiata*, the individuals of which are characterized by the possession of four *branchiæ* or gills arranged on each side of the body in pairs. The *Lamellibranchiata* are all aquatic animals, and the greater part inhabit the sea. Of the fresh-water kinds, the *Anodonta* and *Unio*, the common round or semi-oval *Cyclas corneum*, and the curious sub-triangular shell of *Dreissena polymorpha*, afford instances of the three native families, the *Unionidæ*, *Sphæriidæ*, and *Dreissenidæ*.

Let us now glance at some of the most important parts of the anatomy of the swan-mussel, which, from the large size of

* Gwyn Jeffreys' *British Conchology*, vol. i.

† From ἀ, "not," and ὀδούς, gen, ὀδόντος, "a tooth."